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ABSTRACT

The 14 articles, which make up the bulk of this book provide an interdisciplinary guide to the management of very low birth weight infants. Following an introduction, the first section, titled "Family Considerations," presents three papers discussing, respectively, parent-infant interaction, cultural variables in pediatric care, and parents' responses to children's problems. The six papers in section 2, "Medical and Development Management Concerns," address the changing perspective on early intervention, intracranial hemorrhage, positioning and position-induced deformities, low birth-weight follow-up at Children's Medical Center, Dallas, Texas, nutrition and feeding screening, and instructions for several feeding techniques. The first of five articles in the third section, "Developmental Assessment and Outcome" presents an introduction to measurement concepts and standardized testing; the remaining papers deal with cognitive/language development, neuromotor development, early childhood intervention, and the "legislative arena." This section also contains a general summary of the contents of the guide. Appendices offer information on car seat support, a maternal support system scale, a feeding questionnaire, a list of organizational resources, and administrative forms. Most of the articles include lists of references. (PB)

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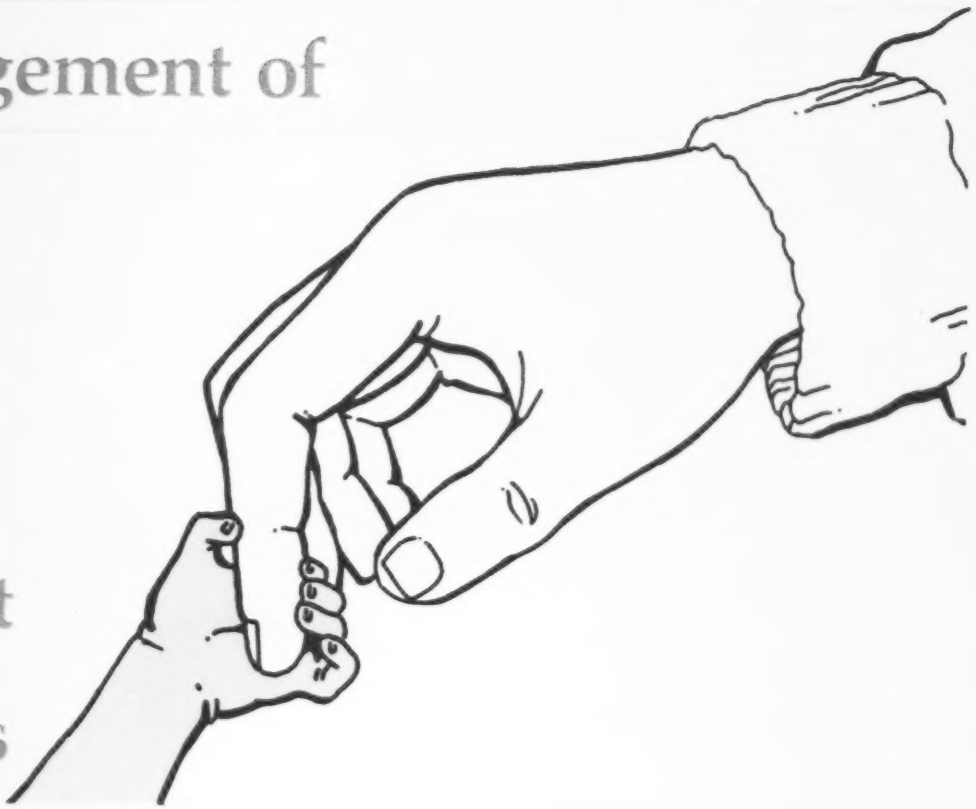

A Team Approach

edited by
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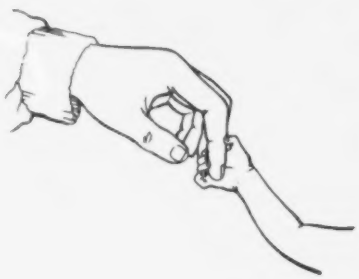

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The participation of Dallas Neonatal Network members is gratefully acknowledged. Through volunteer interagency cooperation, great strides have been made to optimize services to very low birth weight infants and their families.

To the contributors to this manual, wholehearted thanks is given for the many painful hours dedicated to compiling, organizing, and writing the chapters.

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Special thanks to Evelyn Langton, a mentor from another profession, and her husband Marion.

And the most special thanks of all go to my family—Maynard, Emma, Desiree, Kristoffer, Damon, Shane, and Micah.

Preface

This book was originally written as a project of the Dallas Neonatal Network, which was a multi-agency project.* The North Texas Chapter of the March of Dimes Birth Defects Foundation funded the coordinator. The broad goals of the Neonatal Network were (1) to provide interagency service coordination to very low birth weight (VLBW) infants born at Parkland Memorial Hospital in Dallas, Texas, (2) to increase professional knowledge regarding the management of VLBW infants and their families, and (3) to facilitate cooperation between the clinical and research members of the team, thus providing follow-up of the developing infants. Specific goals set each of three years helped address the broad objectives.

Each of the programs with participants in the Neonatal Network deserve special thanks:

Baylor University Medical Center
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Dallas County Health Department
Dallas Easter Seal Society
Dallas Independent School District, Project KIDS
Dallas Services for Visually Impaired Children
Helping Hand Development Center
Parent-Infant Training Center
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Texas Department of Human Services
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This book provides a practical interdisciplinary guide to the management of VLBW infants without duplicating currently available medical or parent books. It provides general recommendations backed up by professional literature cited as the rationale for management suggestions whenever possible. Discipline-specific and highly technical recommendations are not included unless indicated. Those wishing to explore specific areas will find references for more information. Although the material in this book is not discipline-specific, some of the recommendations are clearly more appropriate for a cluster of disciplines, such as nursing and medicine, whereas others are more general.

Because little information is available on managing the health and developmental care of VLBW infants and helping their families cope, many of the recommendations are a "best guess" based upon current knowledge. Authors sometimes base their recommendations on the available literature, a technique that is fraught with methodological problems. *Suggested protocols must be considered only as guidelines until more definitive information is available.*

We hope this book will stimulate interest in and enthusiasm for continued research into appropriate methods for managing VLBW infants and their families.

*Note: The Dallas Neonatal Network, which is no longer operating under that name, is not associated with the neonatal nursing journal, *Neonatal Network*.

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Introduction

by Caryl J. Semmler, Ph.D., O.T.R.

Scope of the Problem

Low birth weight is the major determinant of infant mortality during the first month of life, when most infant deaths occur. In the United States, approximately 7% of all infants weigh about 2500 grams or less at birth and about 1.15% weigh 1500 grams or less. Over 40,000 very low birth weight (VLBW) infants are born each year. Half of the neonatal deaths are very low birth weight infants. The relative risk for neonatal death is almost 200 times greater for VLBW infants than for normal birth weight infants, and the relative risk for postneonatal death is 20 times greater.

McCormick (1985) noted that black mothers are approximately twice as likely as white mothers to deliver VLBW infants (2.4% vs. 0.9%). Infant mortality from 1977 through 1979 averaged 13.6 per 1000 live births, with mortality being 11.9 per 1000 for babies born of white mothers and 22.8 per 1000 for babies born of black mothers.

In addition to increased mortality, VLBW infants also show increased morbidity compared to full birth weight (FBW) infants. As noted in detail in succeeding chapters, the incidence of neurological sequelae, delayed development, lower intellectual and language abilities, and certain health problems requiring hospitalization are greater in VLBW than in FBW infants. Researchers have noted an increased incidence of abuse or neglect of VLBW infants, although they lack objective evidence for this association.

The problems of the VLBW infant are substantial for any family but are amplified with lower-income families who may also have limited education, transportation, and access to telephones.

Levels of Care

Hospital care of the newborn depends partially on the level of care provided by the nursery. According to the *Guidelines for Perinatal Care* (1983), the following levels apply.

- Level I facilities normally handle only routine newborn care.
- Level II facilities have personnel available to manage the problems of high-risk mothers and neonates.
- Level III facilities have personnel to provide perinatal services for *all* mothers and neonates regardless of risk assessment, and they have ventilators and other equipment to manage a seriously ill neonate.

Unfortunately there are no uniform standards specified for Level III facilities; therefore, the extent and type of services such facilities provide to infants vary. Very low birth weight babies will generally need a Level III nursery.

Age of Preterm Infants

The gestational age of an infant is the length of time the baby was in utero, usually expressed as the number of weeks the pregnancy lasted. Lubchenco (1976) describes this age as an estimate based upon obstetric or pediatric measurements. Obstetric estimates of gestational age may be determined by any of the following factors: the length of time since the mother's last menstrual period, the height of the uterine fundus above the mother's pubic bone, the time the mother begins to feel fetal movement, the onset of fetal heart sounds, ultrasound assessment, and laboratory assessments of amniotic fluid. All of these obstetric procedures have limitations that affect the reliability of the gestational age estimate.

An assessment of physical and neurological characteristics of the baby aids in the pediatric determination of gestational age. Some gestational age assessments have been developed by Dubowitz et al. (1970), Brazie and Lubchenco (1974), Finnström (1977), and Ballard (1977, 1979). Typically an evaluation for gestational age focuses on physical characteristics such as skin texture, amount of creasing on the feet, firmness of the ears, amount of body hair, and extent of genital and breast formation. Neurologic examination includes range of movement of the ankles and wrists, degree of resistance to moving the heel to the ear and the forearm across the chest, and resting posture in various positions.

Gestational age is an extremely important factor for predicting outcomes and managing infants. Just as one would not expect a newborn and a 3-month-old baby to have the same developmental and health characteristics, neither can one expect to compare a baby born at 27 weeks gestation with a 40-week baby.

In order to compare preterm with term infants, an age adjusted for prematurity can be calculated. This age is based upon the predicted due date and may be referred to as the adjusted age, the corrected age, or the conceptional age. The term "conceptional age" is usually applied to babies still in the Special Care Nursery. (For example, a 27-week gestation baby may receive visual evoked response testing at 36 weeks conceptional age.) Once the baby leaves the hospital, the terms "adjusted age" or "corrected age" are more frequently used, especially for developmental evaluation.

Steps to calculate an adjusted age:

1. Obtain the best estimated gestational age (EGA) of the infant in weeks from the medical records. If available, an EGA assessed for research purposes may be more accurate than one estimated by house staff or inexperienced personnel. *(For example, EGA = 37 weeks.)*

2. Subtract the estimated gestational age from 40 weeks (which is term) to determine how many weeks the infant is preterm. Multiply by 7 to obtain the number of days of prematurity. *(40 – 37 = 3 weeks preterm, or 21 days.)*

3. Calculate the child's chronological age by writing the evaluation date: year, month, day, borrowing 30 days from the month column. *(90-11-03 becomes 90-10-33.)*

4. Then subtract the baby's birthdate: year, month, day. *(90-10-19.)*

5. Subtract the number of days the infant is premature (step 2) from the chronological age to obtain the adjusted age. *(14 days chronological minus 21 days preterm = minus 7 days adjusted age.)*

Depending upon the method of adjusted age calculation used, the age can vary by a few days, which can make a difference on standardized developmental assessment scores. Always use the same method for consistency.

If, and how long, to adjust for prematurity has not been defined, because the reason for adjusting may vary. Clinic or agency policy may be a determining factor. Follow-up centers may or may not adjust for prematurity when considering immunization schedules, introduction of solid foods, and qualification criteria for developmental intervention services. The younger the child, the clearer the difference resulting from adjusting for prematurity. In standard developmental testing, the difference will be substantial for a child scored as 7 months chronological age as opposed to 4 months adjusted age. By elementary school age, a difference of three months should be irrelevant for essentially any purpose, although in cases where a child is borderline for qualifying for special education services, it can still sometimes make the critical difference in test scores.

The outcome is often completely satisfactory for preterm infants, as these formerly VLBW twins demonstrate at 10 months chronological age.

Because standard guidelines have not been established for how long to correct for prematurity, it is common to report both adjusted and non-adjusted scores on developmental tests for as long as the scores are different. This varies with the test used, the age of the child, and the extent of the child's prematurity.

Ting and Mauk (1986) conducted a study to determine the amount and duration of correction for prematurity that would give the most stable consecutive developmental quotients on the Revised Gesell Developmental Schedules. The subjects were 31 preterm infants with birth weights of 500 to 1500 grams. Language and adaptive behavior scores were calculated using 100%, 50%, and no correction for prematurity. Correction was used for the 100% and 50% calculations until 12, 18, or 24 months. Comparing earlier corrected scores and later uncorrected scores, the investigators concluded that using a 50% correction correlated more closely with later outcome than did using either 100% or no correction.

If the examiner does not use the corrected age for determining developmental indices, as on the Bayley Scales of Infant Development, the rate of false positives goes up. Infants are identified as abnormal or developmentally delayed who fall within normal limits upon later follow-up. On the other hand, some of the more subtle abnormalities may be hidden if the examiner does not adjust for prematurity. It is important to consider this matter because the test scores obtained with adjusted versus chronological age may determine whether a child qualifies for infant intervention services.

Parents, too, should understand the concept of chronological versus adjusted age, because this can influence the health care and educational services

provided for the child. Although professionals may caution parents not to expect their preterm baby to begin eating solid foods nor to sit up and walk at the same chronological age as term infants, it is important that the parents' expectations do not go to the other extreme. Sometimes parents deny even severe developmental impairments in their baby.

Medical Complications of VLBW Infants

Preterm infants present a unique set of medical problems that affect neonatal and follow-up care. Some of these problems may be unfamiliar to community allied health and education professionals but are significant factors in deciding on the programming for these children.

Bronchopulmonary Dysplasia: A chronic lung disease that often results from the use of a respirator.

Intracranial Hemorrhage: Bleeding within the brain, usually around the ventricles, which occurs in a high percentage of VLBW babies. Infants with large hemorrhages develop post-hemorrhagic hydrocephalus.

Retinopathy of Prematurity (ROP): Formerly called retrolental fibroplasia (RLF), this is an eye disorder that results in abnormal proliferation of retinal blood vessels and in severe cases results in retinal detachment and blindness. ROP occurs in about 22% to 45% of babies weighing less than 1000 grams at birth.

Necrotizing Entercolitis: An inflammation of the intestines that may result in the death of a portion of the intestine and may require a temporary colostomy or ileostomy. If too much intestine is removed, the baby develops "short-gut syndrome." This may require IV nutrition because of the baby's inability to absorb enough nutrients through the intestines.

Rickets of Prematurity: A bone disease that develops most commonly in infants who weighed less than 1300 grams at birth. It is characterized by severe bone demineralization. Babies with this disease may experience multiple fractures, particularly of the ribs.

Summary

Very low birth weight infants contribute substantially to infant mortality and morbidity statistics. These infants present special challenges to the health and education systems, especially when they are from lower socioeconomic groups. Early post-hospitalization management of the VLBW infant requires a thorough understanding of the consequences of prematurity on the part of both health care professionals and parents.

Definition of Terms

NICU: Neonatal intensive care unit.

Low Birth Weight (LBW): Birth weight of 2500 grams (5 pounds 8 ounces) or less.

Very Low Birth Weight (VLBW): Birth weight of 1500 grams (3 pounds 5 ounces) or less.

Extremely Low Birth Weight (ELBW): Birth weight of 1000 grams (2 pounds 3 ounces) or less.

Gestational Age: The length of time the baby was in utero.

Term: Born at 37-42 weeks gestation. (The average pregnancy is 40 weeks.)

Preterm: Born at 36 weeks or less gestation.

Full Birth Weight (FBW): Weight that falls between the 10th and 90th percentiles for an infant born at term.

Appropriate for Gestational Age (AGA): Weight that falls between the 10th and 90th percentiles for the infant's gestational age.

Small for Gestational Age (SGA): Weight that is less than the 10th percentile for the infant's gestational age.

Large for Gestational Age (LGA): Weight that is greater than the 90th percentile for the infant's gestational age.

Chronological Age: The age of the child calculated from birth.

Adjusted Age, Corrected Age, or Conceptional Age: The age of the child calculated from conception (age adjusted for prematurity).

Neonatal Period: 0 to 27 days after birth.

Postneonatal Period: 28 days to 11 months of age.

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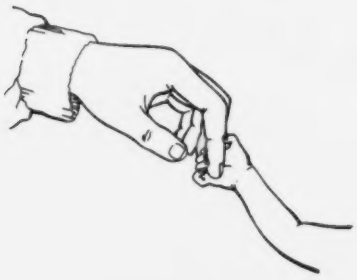

Family Considerations

Parents' Responses to a Child's Problems

by Barry L. Borland, Ph.D.

For most parents, the idea of bringing forth and raising a child elicits feelings of promise and hope. The anticipation and then the actual presence of a baby mark a significant transition for a couple, particularly with their first child. Expectant and new parents respond to the changes in predictable ways. They plan for the child's future and modify their home to accommodate the newest member of the family. Grandparents and other relatives generally view the presence of this new person with enthusiasm. For everyone involved, the birth of a baby is a happy, positive experience. In the vast majority of cases, the new baby seems to be the child who was expected, and family members assume or continue to play their roles as they had anticipated.

Sometimes, however, the child who comes into the world differs significantly from the baby whom the family anticipated. The parents may perceive that they have lost the infant they expected and in its place is some other child, one that does not match the image in their minds. This new child, the *real* baby who is theirs to care for now and always, appears to be very different from what they had imagined. This child may hold out little hope of attaining the goals that the parents have set. In the case of the VLBW infant, the child may require considerable special care, which puts additional emotional and financial burdens on the family.

Learning that a newborn child has a serious problem may create a crisis in the lives of the parents. The perception that they have lost the child they had expected often produces a response that closely resembles the reaction of individuals to other serious life reversals, most notably the loss of a loved one through death. Olshansky (1962) was one of the first social workers to draw an analogy between the responses of parents to the birth of an impaired child and the reactions of individuals to other types of losses, such as the death of a loved one, the loss of a marriage or job, or the destruction of a home through natural disaster. Olshansky's conception of parental reaction to the birth of an impaired child has had a great deal of theoretical and practical significance for

professionals working with families of children with special problems that begin at birth. His original article has stimulated considerable thought and study, and today a much clearer picture of the typical parental reaction to a child with special needs exists in the professional literature.

A clear understanding of how parents respond to their child's problems is necessary for establishing and maintaining a working relationship with the parents, and it provides the basis for effective intervention when necessary. The following discussion summarizes the grief process and how it applies to the birth of a child with special problems, such as very low birth weight.

Parent-infant bonding, or attachment, generally begins with anticipating the arrival of a child who is healthy, attractive, and lovable. Parents expect this child to be a source of pride who will meet their present and future expectations. When the child who does come into the family—the *real* child—differs considerably from the expected child, the family experiences a bereavement. This may be the most significant loss a parent ever faces, one with a lasting effect on the whole family. A loss of this nature requires that parents sever their emotional ties to the expected child and begin to attach to the real child.

Grief

The steps involved in severing emotional ties to the expected child and attaching instead to the real child require a person to go through a grief process. Grief is the aching feeling of sadness that usually is associated with a significant loss. It involves intense mental suffering, sharp sorrow, and painful regret. Grief is a healthy, essential, and very normal response to an abnormal and unexpected event, such as the birth of a child with many problems. Grieving is an adaptive process, a way of coping that usually moves through specific emotional stages. Although different terms may be used to describe the stages, the consensus is that the grieving person experiences the following feelings—usually all of them:

1. Shock and disbelief
2. Denial
3. Sadness, depression, and anger
4. Adaptation or conditional acceptance
5. Resolution or reorganization

Three primary factors affect the length of the grieving process and the pattern of emotions involved: (1) personal characteristics of the individuals involved, (2) external forces, such as actions of other people, and (3) the nature of the loss. Not everyone goes through the stages in the same order, nor does

everyone experience every step, although most people do. Many times, a grieving person regresses and experiences different stages more than once.

Grieving involves a healthy pattern of coping behaviors for adapting to emotionally traumatic events and circumstances. Although the emotional trauma associated with prematurity differs considerably from that attached to the birth of a child with more severe handicaps, the parents' reactions may follow a similar course. The intensity and length of that response can vary greatly. In the following sections, *prolonged or unhealthy grieving* refers to unusually intense responses that may interfere with the parents' ability to resolve their grief. In extreme cases, the parents' behavior may be considered *maladaptive;* this type of grieving may endanger the parents' health or interfere with their ability to care for their child.

SHOCK AND DISBELIEF

Feelings of shock and disbelief are usually intense, but they last only for a brief period of time, sometimes only a few weeks. The parents gradually move from social isolation toward social participation. They may gain a limited awareness and understanding of the problem. People in this stage of adaptation may show some or all of the following behaviors:

- Crying, sighing, heart palpitation, loss of appetite, insomnia.
- Exhibiting either restless agitation or a slowing of activity.
- Showing diminished ability to think, solve problems, and concentrate.
- Manifesting confusion and doubt about the diagnosis and the health care professionals' recommendations.
- Expressing severe disappointment. The ability and desire for social interaction may be limited to one's spouse, or to a very close friend or family member.
- Asking "Why me?"

Unusual, maladaptive behaviors associated with shock and disbelief may involve intense and prolonged confusion and social and emotional withdrawal, such as any of the following:

- Taking to bed for an extended period of time.
- Refusing to consider the child's diagnosis.
- Withdrawing from social and emotional contacts.
- Demonstrating an inability to function in everyday life because of intense difficulty in dealing with feelings.
- Drinking to excess.

DENIAL

Generally there is a gradual transition from shock and disbelief into denial of the diagnosis or the implications of that diagnosis. Denial is an extension of

shock and disbelief, a way of dealing with the reality of a serious life reversal gradually. The following behaviors usually are observed in the denial stage:

- Continuing to doubt the diagnosis and to question the qualifications of the doctors or other medical professionals and their role in identifying or even causing the problem.
- Presenting reasons why the doctors or other professionals may have misdiagnosed the child.
- Seeking opinion after opinion from various professionals.
- Continuing to ask "Why me?"

The period of denial may be prolonged if the child's appearance is not unusual, if the defect is not life threatening, or if the behavior is not obviously uncharacteristic for the child's age.

The denial stage may be very frustrating to professionals working with the child. As a professional, you may feel that you have not explained the problem convincingly and that the parents question your competence and credibility. Usually, however, the parents' denial results primarily from their own inability to tolerate the pain of facing reality suddenly and squarely, rather than from your professional conduct.

Parents whose denial is extreme or prolonged present special problems for professionals. Unhealthy denial may appear in several ways:

A parent must adapt to the unexpected preterm baby.

- Refusing to discuss a potential problem or avoiding a professional evaluation after screening tests indicate such a need.
- Going to great lengths to justify denial of a problem with inappropriate attempts to make the child appear normal.
- Threatening legal action against professionals for what the parents consider to be an inappropriate diagnosis (for example, mental retardation).

SADNESS, DEPRESSION, AND ANGER

Over time, it may become obvious to the parents that their child has special problems. At this point, they start to feel sad and angry. The following behaviors are characteristic of parents in this stage of the grief reaction:

- Exhibiting mood swings, ranging from periods of depression to outbursts of anger.
- Acknowledging that the child has a problem but denying many of the implications of the problem.
- Feeling guilty that the behavior of one or both parents may have caused the problem, even though that activity may have seemed innocent and trivial.
- Losing self-esteem.
- Blaming a spouse, relative, physician, or other professionals for the problem.
- Continuing to question the competence of professionals, particularly when intervention does not produce sudden and dramatic improvement.
- Continuing to ask "Why me?"

In unusually extreme cases of sadness and anger, you may see the following maladaptive behaviors in parents:

- Exhibiting mood swings so frequent and intense that relations with family, co-workers, and friends are adversely affected.
- Internalizing the anger, leading to physical symptoms such as headaches, stomach problems, and chronic fatigue.
- Talking about or attempting suicide because of guilt feelings. The parents may believe that they caused their child's problems, or they may wish that the child had not been born or had not survived. These wishes may be conscious or unconscious.

ADAPTATION OR CONDITIONAL ACCEPTANCE

Adaptation and conditional acceptance are gradual processes that indicate real, positive movement toward resolving grief feelings. In the adaptation stage, the parents show increased awareness and understanding of their child's problems. They feel less sadness and anger, and they tend to direct their anger at the way treatment or therapy is being provided, rather than at the label or diagnosis of their child. Some parents come to a conditional acceptance of their child's diagnosis. Conditional acceptance is illustrated in the following types of examples:

- Stating that the child has a particular physical or mental problem, but minimizing the impact it will have on the child's future.
- Agreeing that the child has a *learning problem* or a severe *learning disability* that will affect the child's ability to succeed in school, but emphatically denying that the child is mentally retarded.
- Continuing to hope that the mentally retarded child can be cured through nonstandard therapies such as special diets or vitamin/mineral supplementation.
- Maintaining the hope that somehow the child will *grow out of* the problem, even while realizing at some level that this hope is unrealistic.

In extreme cases, the parents' feelings may be so intense that negative consequences follow for themselves or the child, as:

- Regarding the child as having *special* positive qualities, even without objective evidence for this belief. For example, the parents may believe that they were sent a child with problems for any of a variety of reasons.
- Resisting placing the child in an existing setting in a school or other program that professionals feel is appropriate.
- Continuing to seek medical opinions in search of a diagnostic label that meets the parents' needs rather than the child's.

RESOLUTION OR REORGANIZATION

When parents can discuss and be comfortable with their feelings of loss, this is evidence that they have resolved or reorganized their grief. Nonetheless, some disappointment and sadness will likely remain. They may accept their child's deficits and resolve their feelings about having lost the child they expected, but most parents will still continue to recall the hopes they had for their child.

Parents in the stage of resolution generally have good coping skills. They are not frequently or easily upset by problems associated with the child's deficits. These parents are comfortable discussing their child's disability and can focus on the future. They are free to concentrate on day-to-day problems of child-rearing rather than on resolving their feelings about the child's disability. Parents who have worked through their grief may seek to learn as much as possible about their child's problem and to become advocates for their child and others with similar problems.

Parents with ineffective coping skills may show very different behaviors, which can adversely affect the child and the family. They may continue to have difficulty talking about the child and the disability. They may show behaviors and express feelings characteristic of earlier stages of the grief process. They may continue to search for causes of the child's disability and to blame people or events for it. The parents' feelings of guilt over their child's disability and their inability to discuss those feelings may lead to further difficulties for the parents and for the family as a whole.

Chronic Sorrow

In the past, professionals tended to view the grief response of parents who have infants with special problems as a sequence of emotions and feelings that were resolved within a fixed period of time. The length of the grief response depended on individual characteristics and the intensity of the loss. However, one study shows that grief does not end when parents have resolved their original feelings of loss. Wikler (1981) questioned parents of developmentally disabled children and found that those parents recycled their grief; that is, they cycled through the grief process several times during the life of their child. Parents reported that they experienced the most intense grief when their child's problem was originally diagnosed. The second most intense period of grief occurred on their son's or daughter's 21st birthday. Throughout the child's life, grief was associated with virtually every developmental milestone. Wikler's study is important evidence that parents of children with lifelong problems experience *chronic sorrow.*

Parents may experience grief reactions and show grieving behavior several times throughout the child's life. Recognize the chronic nature of the parents' grief and acknowledge their needs whenever they experience feelings of grief.

Helping Grieving Parents

In the first stage of grieving, parents need understanding, information, and support. Inform the parents of professional resources that exist to meet the needs of their child. This information can reassure them that their child's case is not hopeless, that they are not alone, and that there are others in the community with similar needs. You may not be able to answer all the parents' questions. Provide whatever information you can immediately, obtain additional information later, and encourage the parents to continue to ask questions. It is essential that the parents become aware of and begin to understand their child's disability at this point. Listen empathically so you can recognize when the parents want more information and when they may feel overwhelmed by that knowledge. Be alert to the parents' need to be alone as well as to their need for the physical presence of an understanding person.

RECOMMENDATIONS FOR THE SHOCK AND DISBELIEF STAGE

Reassure the parents that their feelings are normal and stem from attempting to deal with a situation for which they are not prepared. They may think they are crazy or unable to adjust emotionally because they are experiencing such intense feelings. If you accept these emotions in a nonjudgmental manner, it will help the parents face them and grieve more openly. However, do not

expect parents who are experiencing shock and disbelief to be able to express all their feelings about their child's disability early in the process.

In many cases, a child's appearance at birth may be unattractive due to prematurity or a congenital defect. Reassure the parents that the baby's appearance is typical for that condition and that the defect is often or usually remediable. This helps parents overcome their shock about the disfiguration and enables them to attach to the child.

RECOMMENDATIONS FOR THE DENIAL STAGE

Continue to reassure and support the feelings of parents who are in denial. Provide additional information as appropriate, and assist them in obtaining a second opinion, if necessary. Refer the parents to other sources of information and support, such as parent groups or members of the clergy. Encourage the parents to begin expressing their feelings. Be alert for signs of maladaptive grieving and refer the parents to a social worker, psychologist, or trained family counselor, if appropriate.

RECOMMENDATIONS FOR THE SADNESS AND ANGER STAGE

Continue to provide reassurance and support as the parents experience sadness and anger. Be aware that anger may be directed at you as a professional who symbolizes the child's disability and problems. Recognize that this anger is not personal. To reinforce the parents' self-esteem, emphasize their positive resources for dealing with the problem. If the parents express guilt, encourage them to talk about and resolve these feelings. Accept negative emotions such as guilt, anger, and sadness without judgment, reproach, or unnecessary probing. Be patient and accepting. Continue to look for signs of maladaptive grieving and go on making appropriate referrals to other agencies.

RECOMMENDATIONS FOR THE ADAPTATION AND RESOLUTION STAGES

Continue to encourage the parents and support their feelings. Reassure them that they have the ability and resources to care for their child. Assist parents in anticipating crisis periods. Continue to provide information, make appropriate referrals, and look for signs of maladaptive grieving.

Recognizing "At-Risk Families"

In reviewing the literature, Wikler (1981) found that divorce occurs no more frequently among families of children with severe developmental problems than among other families. Some families claimed that having a child with

serious problems brought them closer together. However, having and caring for such a child places a burden on the parents that can be extremely stressful. Although the pressure may not bring about a divorce, it may result in family dysfunction and instability.

The extent of family crisis is a function of the family's interpretation of the child's disability and the availability of resources to manage problems that create stress. Interpersonal resources within the family may prevent the burdens of care from becoming stressful. Similarly, being surrounded by a tolerant and supportive extended family and community may reduce the pressure on the child and on the family.

The parents' coping abilities can tell you a great deal about how they interpret their child's problem and how much support they are receiving from the rest of their family and from the community. Maladaptive coping at each stage of the grief cycle indicates insufficient personal and interpersonal resources and perhaps a need for therapeutic intervention. You need an acute awareness of adaptive and maladaptive grief responses to identify parents who are not coping with the stress of their child's problem and to make good decisions about management and referral.

Because individuals perceive and cope with problems in their children in different ways, fathers and mothers can be expected to grieve differently. This can affect a marriage because it decreases the ability of one mate to reduce the stress on the other. Differences in grieving style may not cause divorce, but they are likely to reduce the life satisfaction of both parents and significantly affect the care they provide for their other children.

Additional Resources

The Centering Corporation
P.O. Box 3367
Omaha, NE 68103

This company has a catalog of pamphlets for grieving families, including grandparents and siblings. Some of the titles include the following:

No New Baby
Daddy: NICU
Low Birth Weight
A Beginning
Parting Is Not Good-bye
No Time for Good-byes
When Going to Pieces Holds You Together
Newborn Death

Katie's Premature Brother
She Was Born, She Died
When Hello Means Good-bye

The Compassionate Friends, Inc.
National Headquarters
P.O. Box 1347
Oak Brook, IL 60521

The national headquarters can provide addresses for local chapters of this support program for grieving families. Brochures and a newsletter are also available.

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Culture: A Significant Variable in Pediatric Care

by Mary Elaine Jones, Ph.D.

Abstract

Patients, doctors, nurses, and other professionals bring their own cultural baggage to their encounters with patients and their families, who may come from other cultural scenes. Health care professionals in the United States have evolved cultural systems with specific language, dress, and codes of behavior. This can lead to a confrontation of cultures when the patient's family is unfamiliar with the situation. In dealing with the problems of a preterm baby, for example, the patient's family may follow a personalistic or naturalistic belief system regarding the causes of illness. Several factors, including ethnic membership, socioeconomic class, and level of education help identify families who are likely to have different beliefs and practices. It is very important to elicit the family's view of the baby's problems. Although members of a particular ethnic group are likely to share general beliefs regarding health care, be sensitive to individual differences in order to reduce the distance between your perceptions and the family's and to ensure that they will comply with your recommendations for the baby.

Recommendations

1. Interview the family to elicit information about their values and goals and their ideas of what caused the baby's situation and how it should be treated, rather than imposing your values, goals, and treatment plan. In this way, you convey respect for the patient and family as individuals, develop meaningful communication, and finally, ensure mutual cooperation.

2. Identify the primary decision-maker in the family. The major caregiver should be included in treatment plans and decision-making. Remember that the primary caregiver is not always the biological mother. Families may have cross-generational child-rearing patterns, particularly where adolescent mothers are concerned. All parents need time to consult with family members before agreeing to treatment.
3. Take time to include social amenities, such as a handshake and appropriate introductions. These gestures convey respect and build trust between you and the patient and the patient's family.
4. Assess the level of physical and emotional support available to the patient and the family. Practical problems such as housing, finances, and child care may be as important as medical treatment or therapy in affecting the long-range relationship between the parent and the child.

The following broad principles can serve as guidelines in working with families in either health or educational settings. To be an effective care provider, you need to make a commitment to study and understand the significance of culture in health care.

A Practical Example

You are assigned to a special project in a country far across the world. As you dress one morning, you bend down to tie your shoes and you cannot straighten up. You are in severe pain whenever you move. Your traveling companion takes you to the nearest infirmary, though neither of you is fluent in the language. As you enter, the sights and smells are vaguely familiar. Despite your pain, you wonder if you should stay. Every word and look conveys a meaning you do not understand. Someone brings you a dark green tea to drink, and the curer or therapist spends a great deal of time talking with you about your social relationships to determine the *cause* of your back pain. From these questions, you know that the curer thinks someone in your social environment has caused your pain and affliction. Eventually, a massage is suggested as the method of treatment.

A Cultural Framework for Examining Medical Systems

You have entered a system of health care you do not understand. Whether you cooperate with the prescribed regimen will depend upon whether the prescription meets with your expectations of how back pain should be treated, your concepts of prevention, and whether the health practitioner can gain your trust and communicate this regimen to you in terms that make sense to you. You have experienced a cultural confrontation in the medical system. When people of different cultures meet, they are unlikely to share the same

expectations regarding illness and treatment. A family that participates in our country's health care may be entering a cultural system as foreign to them as the one in the hypothetical example above.

Two points are important to remember:

1. A health care delivery system is a culture characterized by the beliefs of the professionals who participate in it. Members of the system ascribe to shared ideas about what causes disease and how it should be treated, how patients should be handled, and how each of the members of the treatment team should behave with each other and with the patients.
2. Patients and their families may not share your model of disease causation and cure, patient treatment, and professional behavior. In the hypothetical example, the curer defined back pain in social terms; you, the patient from a different culture, probably had a more physiological explanation for the cause of the pain.

Basing their ideas on cross-cultural study, anthropologists maintain that there are certain universal beliefs common to all cultural groups. Illness and its attendant pain and suffering occur everywhere. However, the interpretation of the meaning of illness and pain is culturally specific, dictated by the rules inherent in a particular social group. All parents care about their children and are grieved when something goes wrong. However, individuals have different ways of expressing this concern. It can be obscured by variations in word meanings, in the definition of health and illness, and in the remedies their culture provides. These differences come into sharp relief in a setting such as a neonatal intensive care unit.

If you, as a professional in a medical culture, wish to communicate with a patient or the patient's family, you must understand their world and beliefs and their explanation of disease and illness. You also need to comprehend your own culture, that of your profession, and the culture of the hospital or institution within which you work. You need to perceive and appreciate the dynamics of interaction between your system and the patient's. Each person in the interaction wears layers of cultural experience much like clothing for a cold winter. To communicate effectively, the layers must be removed as needed to reach an understanding of each situation.

Understanding the Patient

The desire for an explanation of the cause of a disease or illness flows into a rational, logical approach to the remedy. In the example of your severe back pain, you probably would have reviewed the events of the previous days to determine what physical activity might have strained your back. You might then have deduced that lifting a heavy piece of luggage caused the injury. Had the pain been less severe, you might have tried several home remedies, such as

a hot shower, a heating pad, or bed rest. You decided to seek help through a logical thought process based on your background knowledge.

Foster and Anderson (1978) described a useful framework for understanding cultural interpretations of causes and treatment of diseases. The explanations may overlap within a given cultural group, but they can be useful nonetheless in understanding the variety of explanations of and treatments for illness.

Personalistic: The prevailing explanation of the cause of the illness or event is a person or supernatural being; for example, a witch, a sorcerer, God, a ghost, an ancestor, or an evil spirit. Some being is the cause of the illness. In everyday life, people give each other headaches, children drive parents to insanity, and insensitive, demanding supervisors can cause a person to experience anxiety and stress-related conditions.

Naturalistic: Illness is caused by a disturbance in equilibrium due to an imbalance of the elements of the body. Frequently, hot and cold forces of the body are said to be out of balance, sometimes relating to actual body temperature, but usually referring to certain qualities of the condition, food, activity, or state of the individual. For example, pregnancy may be classed as a hot condition. In order to bring the body back into balance, cooling activities might be employed.

This framework is useful in understanding the *remnants* of beliefs and practices a health professional is likely to encounter in working with patients and their families who may adhere to more traditional ways of believing. By contrast, for scientific Western medicine, the explanation of the cause of a disease or illness is related to the germ theory or to physiological dysfunction.

Patients and their families may have different ideas from yours about the cause of their problem. Even professionals may not share the same explanations for a patient's condition or illness. On the other hand, portions of the explanatory model may be shared by more than one cultural group.

Harwood (1981) summarized predictors of patients who are likely to have a belief system about health and illness that is significantly different from that of the professionals involved. Harwood's predictors have been adapted for use as a triage tool or as an adjunct to assessment of the patient and family. Such an approach should be used to assess *all* patients who enter the health care system.

- Lower level of formal education (less than high school)
- Recent immigrant status (first generation or less), or rural origin
- Close ties to the ethnic and family social network
- Little experience with medical services in present environment
- Little experience with illness in immediate family
- For immigrants, moving at an older age
- Frequent migration back and forth to the mother country

Once you have determined which patients are likely to adhere to different beliefs, the next step is to decrease the barrier of *cultural distance* and establish an effective working relationship with them. Kleinman (1978) offered a method of clinically assessing cultural factors that revolves around individualized patient care. Kleinman proposes that the professional must actively elicit the patient's perception of the cause of the illness or condition, the pathophysiology, the prognosis, and the methods of treatment that the patient thinks should be administered. Generally, professionals impose ideas of cause and cure without asking what the patient perceives. Eliciting the patient's perception requires sensitivity and an ability to listen for clues about the meaning of the illness or event.

The following adaptation of Kleinman's questions is useful with families of premature infants. These questions can be integrated into the data collection and interview part of the clinical encounter. They are most effective in eliciting a true picture of the family's understanding and beliefs after you have established rapport and trust.

1. What do you think has caused your baby's problem? (What does your mother say? What does your grandmother think?)
2. Why do you think the baby was born when it was?
3. How do you think the baby's prematurity (coming so early) affects him or her now?
4. How bad (severe) do you think the baby's prematurity is? In your opinion, will the effects last a long time, or will the baby be better soon?
5. What kind of treatment would you like to have for your baby?
6. What are the most important results you hope your baby will get from treatment?
7. What are the chief problems having a premature baby has caused you and your family?
8. What do you fear most about having had a premature baby?

Then compare the patient's explanation of the cause and cure with your own. How do they differ, and how are they the same? After comparing, negotiate the differences. While it may seem a simple task, the negotiation itself may be time consuming, as the following example demonstrates. During a prenatal class on preparation for labor and delivery with a group of adolescent mothers, an instructor stated that following delivery, most mothers feel good, they are hungry, and they want to take a shower. A 17-year-old, pregnant with her second baby, was adamant in saying that she did not believe bathing after giving birth was a good idea. Her mother and grandmother told her *not* to bathe because "you're open there and you can get an infection." She admitted that while in the hospital with her last baby, she pretended to shower by turning on the water but never actually got wet. The instructor paused as she realized that she too believed "you're open." However, she also understood that water was cleansing and a shower—as opposed to a bath—was not dangerous. The task of negotiation was complicated because the rest of the

class were also waiting for an answer. Finding a common area of agreement and highlighting the difference between a bath and a shower as a way of cleansing were the important factors in the negotiation process. The instructor said she realized that a lot of people felt that way, and she did, too, but only in relation to tub baths. She distinguished between tub baths and showers as ways to get an infection. This was only a beginning step in comparing each other's ideas, but it demonstrates the necessity to elicit differing explanations, compare them, and finally negotiate.

All patients deserve an opportunity to express their understanding of cause and cure. Kleinman's model calls attention to the need to individualize care based on how the patient and the family understand and accept what has happened to them.

The Dangers of Generalizing

There are risks in discussing the concept of culture or ethnicity. One obvious pitfall is the simple denial that differences exist. On the other end of the continuum, and almost as dangerous, is romanticizing or overemphasizing cultural differences. People become exotic objects of study instead of remaining human beings. Be aware that the differences between ethnic or cultural groups become meaningful only when you view them by observing individuals from these groups. Define each situation and learn about another culture through the eyes of one of its members. This is the first step in eliminating barriers. Keeping in mind the concept of the universality of all people, note that it is still helpful to know some of the *differences* between ethnic groups and to have information about how people think, their health practices, and their family structure. The reference list at the end of this chapter offers sources of information for the major ethnic groups. Harwood (1981) contains information on seven ethnic groups, including urban blacks, Chinese-Americans, Haitian-Americans, Italian-Americans, Mexican-Americans, Navajos, and Mainland Puerto Ricans.

Several additional points are important when reading the literature and making generalizations about cultural groups. Not every member of a culture feels the same sense of solidarity. Factors such as age, sex, social class, religion, location, and mainstream patterns of change affect a person's adherence to traditional practices and beliefs. Every ethnic and cultural group contains members who are destitute and poorly educated, others who are wealthy and highly educated, and still others who fall somewhere between these extremes. Each person along the continuum will react to life differently, but it is often hard for an outsider to determine whether these behaviors result from cultural or from socioeconomic differences. Bullough and Bullough (1972) wrote a useful volume that examines poverty and health care.

The additional burden of caring for a sick or handicapped infant can add a significant amount of stress to an already burdened parent or family. Belle (1982) studied the life contexts of low-income mothers to determine the cause of a high incidence of depression. She found that these mothers experienced unpredictable income, unrelieved child care responsibilities, inferior housing, inadequate employment opportunities, and dependence on community agencies, as well as crime and discrimination. The study associated depression with these long-term problems rather than with a single crisis or event. The stress of such a lifestyle affected the mothers' mental health, and ultimately, the mother-child relationships. Women with social support, especially assistance with child care, experienced less depression.

Pascoe et al. (1981) studied 69 black and white rural families of children discharged from a neonatal intensive care unit. They found that social support was a significantly more important determinant of adequate home stimulation for a child than changes in the mother's life. The authors concluded that attention to maternal social support networks can influence the home environment and increase a child's learning opportunities.

Understanding the Hospital Culture in the NICU

Throughout a lifetime, each person experiences a number of different *cultural scenes*, which are similar to what Spradley and McCurdy (1972) call recurrent social situations. Banks, churches, schools, prisons, and hospitals are examples of cultural scenes. The individual learns the rules of behavior, terminology, and dress of a particular scene in order to function comfortably within it. A person living in a complex society experiences a number of different situations, some of which share characteristics. However, individuals bring different experiences and perceptions to each cultural scene, even if it seems similar to something else in their lives. The concept of *cultural scene* can be applied to the hospital and, specifically, the neonatal intensive care unit. The cultural scene of the hospital and its personnel is yet another factor that obscures real communication between the patient and the professional.

Hospitals exist to preserve life and safeguard its quality. Many hospitals also have a teaching function. The hospital may be affiliated with schools of medicine, nursing, and related health sciences. A city-county hospital that serves primarily an indigent population has the additional responsibility of taking care of patients with few economic resources. The people who work within the cultural scene of the hospital share the basic purpose of saving lives and maintain clearly defined roles and relationships in order to accomplish this task. Doctors interact in certain prescribed ways with nurses, nurses with social workers, and social workers with therapists. Each profession has its own culture with values, beliefs, codes of behavior, and even stereotypes of other professional groups. Similarly, certain perceptions of patients are shared across

disciplines, whereas others are unique to a particular specialty. Sometimes communication among professionals from various disciplines is not useful because of differences in values and beliefs. The effectiveness of interaction between specialties is determined by shared beliefs and by the willingness of each discipline to understand others' views.

Bogdan et al. (1982) described factors influencing staff-parent communication on neonatal units. They observed and interviewed staff members in several urban teaching hospitals to determine how they classify patients admitted to a neonatal unit, how they categorize parents, and how they see themselves. On admission, a patient is classified as either a *baby* or as *nonviable*. *Nonviable* infants do not receive treatment. A *baby* receives treatment and is further classified as *a very sick baby, a baby with special problems,* or *a good baby.* A good baby is judged to be at low risk for dying. Subcategories within each designation describe additional characteristics of the baby. One kind of good baby is on the unit for observation and for supportive care. Another kind is the *feeder and grower,* the basically healthy baby who is on the unit for weight gain and minor problems. Staff members make risk assessments and talk to the parents based in part on the category in which they have placed their baby.

Staff members also categorize parents as *good parents, not-so-good parents,* and *troublemakers,* and maintain broad expectations about the behavior of these classifications. Age, ethnic membership, and economic status are among the characteristics the staff use in typing parents. "Good parents" visit regularly, demonstrate evidence of *bonding* with their child, understand and conform to unit rules, are realistic about their baby and easy to talk with, and show potential to care for their baby adequately upon dismissal. "Not-so-good parents" are perceived by staff as not being able to understand the condition of their infant, as not visiting the infant, or as lacking the necessary resources to care for the infant. "Troublemakers" are demanding or assertive and may be perceived as overly critical or dissatisfied with their baby's care.

What the staff tells parents about their babies seems to be influenced by how the parents and infants are classified and by the principles *you never can tell what the outcome for a particular infant will be* and *be honest but not cruel.* What parents *hear* is contingent not only on their beliefs, but also on the dynamics of the events that surrounded the birth of their baby. Because of this, what the professionals think they have said to the parents and what the parents hear do not always match.

According to Bogden et al. (1982), effective communication requires seeing the event from the participant's viewpoint within the context of the setting. The parents are experiencing a foreign technological environment. The beliefs they superimpose on this cultural scene may significantly affect their perception of events and, ultimately, the entire communication process. Technical language is only one of the barriers. Parents are also likely to have stereotypes about what a *good* nurse or doctor says or does.

Patient-Professional Interaction

What happens when you meet a patient or the patient's family within the health care delivery environment? If each of you comes with a set of cultural values, then the answer is "a lot." A systems analyst might depict the encounter as two intersecting circles with some amount of congruence, as in Figure 1. Each circle represents a person who comes complete with a unique body of experiences, beliefs, and values. You bring your own beliefs, experiences, and socialization as a member of each of the following: a profession, a specific cultural group, and a bureaucratic organization. The hospital itself imposes yet another layer. Similarly, the patient's or the family's beliefs depend on their background and experiences. You and the patient's family may or may not share many life experiences. In multi-cultural settings, such as urban city-county hospitals, many combinations of interactions are possible, depending upon the ethnic membership of the patient and the professional. Figure 2 depicts some of the possible interactions among people if you consider only the factor of ethnicity. In any setting within the health care delivery system in the United States, any combination of cultural interactions is possible. Within the neonatal unit, many different disciplines interact, which adds a second level of participation. Interactions occur among disciplines, and these specialists also contribute individually to the care of the patient and the family. Small wonder a family with limited experience with the health care system may be confused!

So far, the interactions between the patient's family and the professional have been considered in only one bureaucratic setting, the hospital. However, these conclusions also apply to the schools, the social agencies, and the public health departments with which patients and their families may have contact. Interagency collaboration around the very low birth weight infant is often difficult because the cultural scene of each institution is different. For example, an educator comes from a learning model, just as a physician comes from a medical model. Though similar in some ways, agencies have differing values and approaches. *Culture brokers* are often the best people to facilitate productive, meaningful communication. Any health professional sensitive to cultural differences can become a culture broker through observation, study, and commitment to recognizing and accepting the differences between people. If institutions need culture brokers, then certainly the families of babies with problems also need them. In fact, both patients and professionals may need culture brokers. If neonatal intensive care units are really to be *care* units, if helping professions are really to *help*, then awareness of differences in perception should permeate all contacts between the family and the professional, among professionals from different disciplines, and among agencies. Sensitivity to individual differences followed by negotiation is the solution whenever there is a confrontation of cultures.

Hypothetical Depiction of Shared Culture

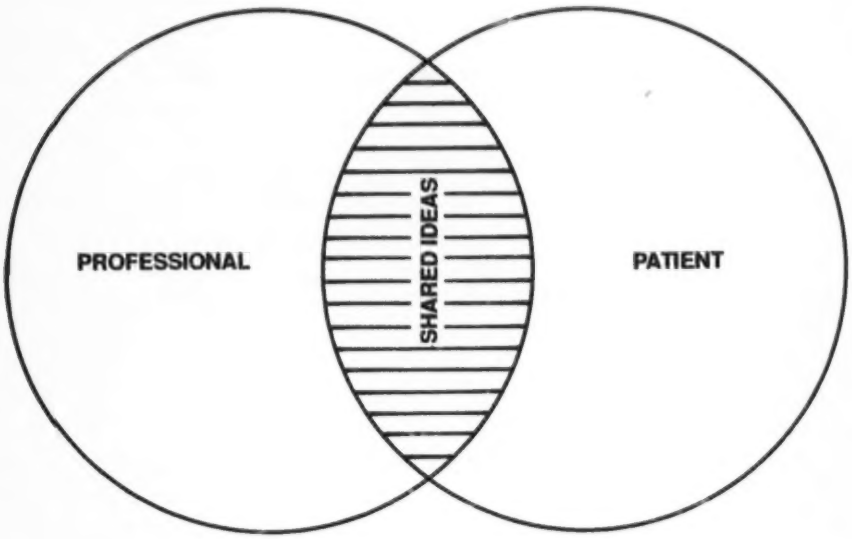

Figure 1

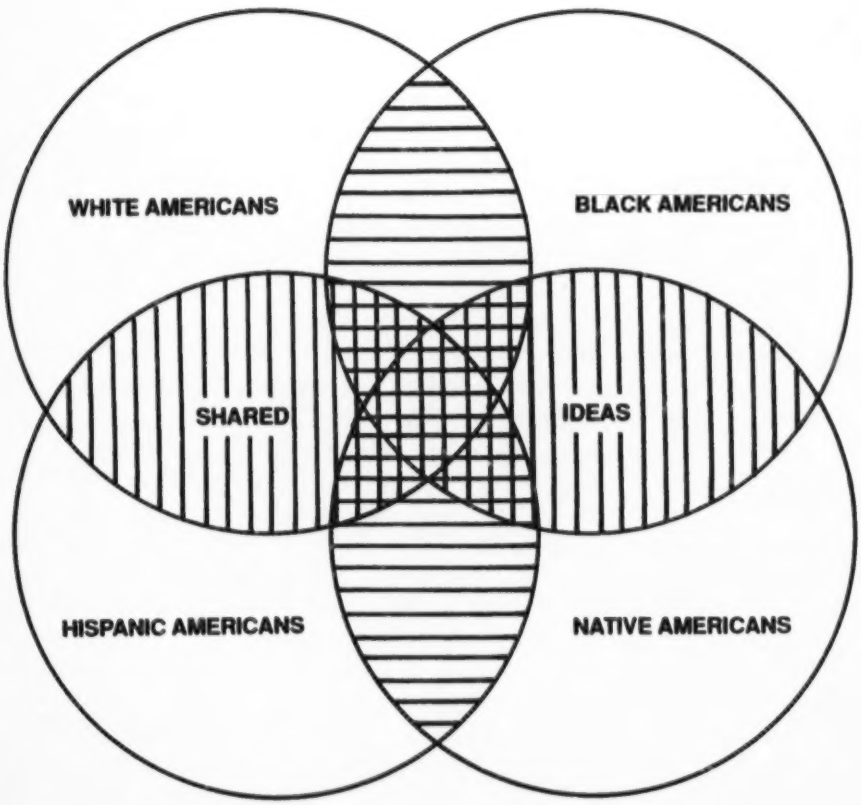

Figure 2

Definition of Terms

Culture: A particular constellation of qualities, values, and learned behaviors that are logical and integrated into meaningful patterns and that people have acquired through membership in a group.

Cultural relativity: The view that customs, values, and cultural norms derive their meaning from the specific context of a group or society's conception of *correct* behavior.

Ethnocentrism: Viewing or judging other cultures solely in terms of one's own culture. The belief in the inherent superiority of one's own group and culture.

Medical system: Culturally based behavior and beliefs arising in response to the threats posed by disease. The medical system is manifested through institutions and cultural traditions that exist in an effort to maintain health.

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Parent-Infant Interaction

by Janice Nici, Ph.D.

Abstract

VLBW babies are at risk for difficulties in parent-infant interaction because of their early isolation and developmental immaturity. Researchers have documented some of the ways mothers interact with their preterm infants that may persist over a period of months. Whether or not early interaction problems contribute to the infants' later outcome, separate from the contributions of developmental delays or low socioeconomic status, is difficult to determine.

Good parent-infant interaction may be related to cognitive development, but the mechanism through which it acts is unknown at this time. Research results suggest that the infant's developmental level contributes to successful parent-infant interaction through a complex set of interactions. A host of environmental and socioeconomic variables also affect the process.

Health professionals should encourage positive parent-infant interaction for VLBW babies. However, one should recognize that a lack of early bonding experience does not preclude later satisfactory relationships, nor do satisfactory interactions within the NICU setting offset the effect of the eventual home environment (Brown et al., 1980). The development of VLBW infants is a product of their innate capabilities, combined over time with family interaction in an environmental context.

Recommendations

1. Instruct the mother and the father to imitate their baby during face-to-face interaction. Field (1977) found that telling a mother to imitate her baby served to lower the mother's activity level and increase the baby's responsiveness.

2. Organize parent groups in the hospital for new parents of preterm infants. Arrange for "veteran" parents to serve as group leaders. Minde (1980) found that such groups provide reassurance to new parents. They can learn what to expect and can see that successful coping is possible.

3. Avoid drawing conclusions regarding parental coping from parents' early emotional reactions. McGrade et al. (1985) found that early reactions were not predictive of later coping. They suggest that professional interventions should be tailored to the individual parent's coping style; care should be taken not to dismiss those parents who appear to be "denying."

4. Demonstrate the baby's responsiveness and interactive capabilities to the parents. For example, show the parents that holding the baby upright and dimming the lights may facilitate eye contact; that encouraging hand-to-mouth or swaddling may console an irritable baby; and that the baby can respond to sounds. Parents may be more comfortable interacting with the infant if they are aware of the baby's capabilities.

5. Provide information to parents on the development of preterm infants. Goldberg (1978) pointed out that parents of preterm infants are as much in need of information as are parents of term infants, so that they can maintain appropriate expectations of their baby.

6. Arrange for extended professional contact and follow-up as appropriate, perhaps through a home-based program. Long-term programs are more effective in securing lasting improvements in parent interactions and infant development than are short-term interventions.

7. Focus intervention on developing the parent-infant interaction. Barrera et al. (1986) found that an intervention based on the parent-infant interaction was superior to one that focused on infant developmental status.

8. Refer for psychological assessment those parents who present signs of emotional disturbance. Blake et al. (1975) concluded that a mother's own psychopathology was the discriminating factor between those mothers who eventually adapted to the birth of high-risk infants and those who did not.

Parent-infant interactions involving very low birth weight infants are of interest and concern because these babies are such poor interactional partners for the early part of their lives. Their medical status causes isolation in the neonatal intensive care unit for varying periods of time, as well as relative deprivation of early interactional experiences with their parents. Their biological immaturity results in poor alertness and a low threshold for stimulation, further impairing their interactional capabilities. Professionals have feared that the mothers would not bond successfully with these babies and that attachment and parent-infant relationships would be disturbed, all to the detriment of the infant's developmental outcome.

To explore whether these concerns are justified and what can be done to promote healthy parent-infant interactions with VLBW babies, this article will examine the factors affecting parent-infant interaction, the related areas of bonding and attachment, and the available research.

When an infant is connected to tubes and monitors, it may be difficult to foster a strong parent-child attachment.

Parent-Infant Interaction Models

Recent interest in parent-infant interaction arose from the recognition that researchers need more complex models to understand behavior and development. Investigators have tended to focus on either behavioral or environmental factors in traditional models of development. Some characteristics, such as personality features, are more appropriately the product of the child as part of a particular environment, rather than as arising from either the child or the environment alone. This interactional viewpoint is consistent with the major theories in developmental psychology.

Several developmental theorists have formulated new models by which to understand and study parent-infant interaction. Thomas et al. (1968), for example, proposed the *goodness of fit* model, based on the hypothesis that family members will function together better if their temperaments coincide than if they are incongruent. Sprunger et al. (1985) found that the degree of congruity between the infant and family on selected variables was related to the family's overall adjustment. Neither the infant's nor the family's characteristics in isolation were significant for adjustment.

Parke (1979) advocated studying parent-infant behavior as an interactional system in which each family member is directly and indirectly affected by interactions with every other family member. He outlined five ways in which a mother, father, and child could interact and affect each other's interactions. For example, the father could influence the mother's behavior toward the infant (F→M→I), or the relationship between the father and the infant could affect the father's and mother's relationship (F-I)→(F-M).

Brazelton and his colleagues (Brazelton, 1980; Brazelton et al., 1974) developed a model of parent-infant interaction that involves cycles of reciprocal interaction, which they describe as being like a dance. The mother and child share alternating brief periods of involvement and recovery, of attention and withdrawal. This interaction is mutually satisfying, provides reinforcement to both parent and child, and encourages the baby's further development (Lester et al., 1985).

Goldberg (1977) and Lewis and Goldberg (1973) presented a model of infant perceptual-cognitive development, the *generalized expectancy* model, in which the infant's motivation is significantly affected by interactions with the mother. They hypothesize that the mother's reaction to the infant's behavior teaches the infant that its behavior can successfully affect its environment.

Measurement Problems

These models have stimulated new research. However, with increasingly complex models come intricate research questions as well as complicated measurement problems. For example, investigators can measure an environmental factor, such as the mother's talkativeness, and they can compute its correlation with the infant's language development at a certain age. Within an interactional framework, however, the mother's talkativeness can be expected to exert a *continuing* influence on the infant, and its power may be different during various periods in the infant's development. It may be helpful at one time and neutral or detrimental at another. The mother's interactions with her baby can also modify her talkativeness. With a verbal child, it is difficult to distinguish the influence of the mother's conversations with her baby from the child's genetic propensity to be talkative due to characteristics inherited from the parents. Finally, it may not be possible to separate the specific influence of the mother's talkativeness from related variables that can affect the child, including the parents' IQs or their socioeconomic status.

To measure parent-infant interaction, most researchers employ some type of observational system, either in the home or in a laboratory setting. Researchers can code specific behaviors of either the parent or the infant, with sophisticated approaches that attempt to standardize aspects of their interaction. One such scale, the Nursing Child Assessment Teaching Scale (NCATS) by Barnard (1978), observes and scores parent-infant interaction as the parent teaches the infant a new task. The observer scores 50 specific behaviors as having occurred or not occurred during the observational period. For example, *Parent smiles or touches child within five seconds when child smiles or vocalizes*. This instrument has normative information for infants up to 3 years of age. The HOME (Home Observation for Measurement of the Environment) by Caldwell and Bradley (1979) is a standardized observational scoring system

that has been very useful in research. Designed primarily to analyze aspects of the infant's environment, the HOME includes some interactional items, such as *Mother talks to child while doing her work.*

The study and measurement of parent-infant interaction is important because poor interaction, or the disruption of early interaction due to separation (such as isolation in the NICU), may affect the parent-child relationship and can have long-term implications for the child's development. Long-term consequences can result if poor interaction interferes with bonding or attachment. Bonding and attachment, although often used interchangeably, actually denote different processes, and the distinction is particularly relevant for VLBW babies.

Bonding

Bonding, as described by Klaus and Kennell (1976), is a biological process whereby a mother develops a special feeling for her child in the period immediately following its birth. Observed first in ethology (the study of animal behavior in its evolutionary and developmental context), bonding is promoted by physical contact and must occur within a *critical period* during which the mother is biologically ready to bond. In humans, separation of the neonate from its mother, either as a result of prevailing hospital practices or because of complications with the birth, was believed to disrupt this bonding process and presumably affect all future mother-child relations. Failure to bond was cited by Klein and Stern (1971) as a risk factor for child abuse.

This concept of bonding has not held up under careful study (Chess and Thomas, 1982; Herbert et al., 1982). First of all, humans are much more flexible in their behavioral adaptation than other animals are, and they are less controlled by critical periods. Follow-up research has failed to show lasting effects on the parent-infant interactions of women who had the opportunity to bond with their infants through extended contact following birth compared with women who had not (Campbell and Taylor, 1980; Rode et al., 1981).

Svejda et al. (1980) conducted a random-assignment, double-blind study to determine whether early contact resulted in a closer mother-infant relationship. They found no differences on any of their measures between the mothers who had the early contact and those who did not. Although the opportunity to hold her baby after birth may be a very positive experience for a mother, she can develop a satisfactory relationship with the baby even if she does not have that opportunity.

The bonding opportunity may not be available to the mothers of VLBW infants because the babies' health status precludes early contact. Such missed opportunities do not doom the parents to an unsatisfactory or diminished

relationship with their child because bonding did not occur. Health professionals should guard against creating a self-fulfilling prophecy, whereby parents of VLBW babies feel guilty and inadequate for not bonding and therefore interact less effectively with their babies.

Attachment

In contrast to the hypothesized biological basis for bonding, attachment has a psychological basis whereby an infant and parent develop strong affectional ties to each other. Attachment develops between the child and the father as well as the mother. Indeed, the term has been broadened to include close affectional ties with siblings and others. Attachment is not an all-or-none event that can occur only at a particular time. Being a more complex process, attachment is difficult to measure. Previously, the amount of anxiety a child showed towards a stranger was taken to indicate the strength of a child's attachment to its mother. More recently, attachment is being measured in more positive ways, such as by the child's behavior upon being reunited with the mother after a brief separation. A child who shows positive reactions on the mother's return is thought to be more securely attached. Hypothetically, this secure attachment provides the child with the emotional security to explore its environment and thus to develop competence.

Attachment is a more useful and robust concept than bonding. Researchers have developed procedures to determine whether a child is securely attached to its mother or not; the more securely attached children have been found to be more competent, independent, compliant, and empathic (Campbell and Taylor, 1980; Sroufe, 1983). It is not known whether attachment characteristics are stable beyond 2 years of age (Thompson et al., 1983), or whether attachment is the significant variable that leads to competence—as opposed to the mother's behavior that may lead to the secure attachment and the positive outcome (Rosenblith and Sims-Knight, 1985). Nonetheless, attachment remains a promising concept as a way to study the dynamic relationship between parents and their children.

VLBW babies may be at risk for difficulties in attachment because their fragile health status precludes normal interaction with their parents. However, recent research offers hope that even VLBW babies can achieve secure attachment, although the parents must make greater adaptations than they have to for less fragile infants. Frodi and Thompson (1985) found that a group of healthy preterm infants had the same proportion of securely and insecurely attached relationships as a comparison group made up of term infants. These authors suggested that the parents were able to adapt to their infants' difficult characteristics and thus in time promoted healthy social-emotional development in these babies.

Early research on VLBW infants revealed that most parents eventually developed satisfactory relationships with their children, as determined by follow-up observation and interview (Blake et al., 1975). Those mothers who did not adjust well to their children had prior psychiatric disturbance. This brief review suggests that VLBW infants and their mothers are usually able to develop satisfactory early relationships, even though they must be considered at risk for attachment difficulties on the basis of current developmental theory.

VLBW Interactional Capabilities

Little research is available on the interactional capabilities and difficulties of VLBW infants. However, research on healthy preterm and LBW infants can provide a background to understand the problems encountered by the smaller, sicker, VLBW babies. Representative studies are summarized in Table 1 and are discussed here.

Preterm and LBW infants generally are less responsive than term infants (DiVitto and Goldberg, 1979). They are less vocal, and they more frequently avert their heads or their gaze when their mothers try to interact with them (Field, 1980). During feeding, they provide fewer clear cues than term infants and respond less to their mothers' social cues (Alfasi et al., 1985). They spend less time playing and smiling, and more time fretting (Goldberg et al., 1980). In contrast to term infants, preterm babies become more irritable after going home (DiVitto and Goldberg, 1979). Although preterm infants tend to improve over time, they remain less responsive than their term counterparts at the end of one year. Those infants with whom early interaction is difficult tend later (at 8-12 months of age) to be less cooperative, more negative, less responsive to tasks, and poorer in endurance (Goldberg et al., 1980). Apparently the social development of these preterm infants was not merely delayed; instead it developed along a different course from that of term infants.

These findings could be extrapolated to the population of VLBW babies on the basis of the authors' distinction between healthy and sick (respiratory distress) preterm infants. On almost all of the measures, the sick preterm infants performed the poorest. Thus it follows that VLBW infants could be expected to have similar or greater problems in their interaction and social development.

Several researchers have also found differences in the behavior of new mothers of preterm infants. Field (1980) found these mothers to be more verbal but less sensitive to their infants' cues. For example, these mothers might continue to talk to their babies, coaxing them to feed even when they were actively sucking. At such times, mothers of term infants would pause in their conversation. Mothers of healthy preterm infants also tended to hold their babies at a greater distance during feeding—in their laps, rather than in their arms, for instance (DiVitto and Goldberg, 1979). Goldberg et al. (1980) found

that parents of preterm infants tended to engage in more touching and more demonstration of toys during play than parents of term infants.

According to Field (1980), the higher activity level of the mothers, particularly during feeding, may have resulted from trying to interact with rather unresponsive babies: ". . . the burden of maintaining the interactions fell disproportionately on the mothers." Field found that a mother's overactivity tended further to *decrease* an infant's responsiveness, as if the mother were overburdening the baby's immature *environmental filtering system*. She suggested that this situation might cause a negative cycle, during which an unresponsive infant elicited too much maternal activity and because of that became even less responsive to the mother.

According to Als et al. (1979), another source of risk for these babies is the prematurity of their *parents!* The parents of a preterm infant do not have as long a time as they had expected to prepare for the baby's arrival. Further, they have to adjust to the possibility that their baby might not survive, and often they go through the grieving process that accompanies the birth of a preterm baby. The VLBW baby will take longer from the time of birth to achieve developmental milestones, resulting in parental disappointment and a feeling that their baby is behind (Goldberg et al., 1980; Lasky et al., 1983). Additional psychological factors that may affect the interactional competence of these mothers (summarized in Table 2) include decreased self-confidence (DiVitto and Goldberg, 1979), concern over the baby's fragility, and a negative bias towards babies labeled premature (Stern and Hildebrandt, 1984).

Surprisingly, however, parental denial and feelings of self-blame have not been found to have a negative impact on the outcome of a parent's own baby. In

Preterm babies can make poor interactional partners.

fact, Affleck et al. (1985) found self-blaming mothers of developmentally disabled infants, including VLBW infants, to function more optimally on follow-up than mothers who blamed others for their babies' problems. The self-blaming mothers had fewer mood disorders and higher HOME scores than other-blaming mothers. Self-blame may have served as a coping mechanism for these parents and may have represented their efforts to find personal control: All of the self-blaming mothers attributed blame to specific behaviors (such as smoking during pregnancy) rather than to enduring personality characteristics. Affleck et al. (1985) also noted that although health professionals often told parents that the etiology of their baby's problem was unknown, 40% of the sample attributed causal factors either to their own or to others' behavior. Another study by Paludetto et al. (1981) found that 70% of the parents attributed a cause to their baby's premature birth, most frequently an obstetrical cause.

McGrade et al. (1985) cautioned health professionals not to draw conclusions from parental behavior during the time soon after a baby's birth. In their study, parental behavior and denial soon after the baby's discharge from the hospital did not relate to the parents' later coping. The study provided families of high-risk (including VLBW) and handicapped infants with home-based intervention designed to promote healthy parent-infant relationships. The researchers rated mothers when their babies were 1 month and 9 months of age on their use of skills learned during intervention, their coping skills, and their emotional reactions. They measured the infants' environmental stimulation using the HOME scores. The mothers' average rating fell in the average-to-good range, which may indicate the success of the home-based intervention. There was no relation between their early emotional reactions (denial, ventilation, anger, and so on) and their later coping mechanisms, their use of intervention skills, or their provision of an adequate and supportive environment. The authors suggested that professionals adapt their services to parents' individual coping styles rather than draw unwarranted conclusions based on parents' early reactions.

Contribution of Parent-Infant Interaction to Outcome

A number of investigators have examined the contribution of parent-infant interaction to infant outcome variables. In a longitudinal study of infant outcome, Sigman and Parmelee (1979) found that their predictions of outcome at 2 years of age were not significant until they included parent-infant interaction variables in the statistical analysis. Other reports indicate that these variables are significant among both term and LBW infants. Bradley and Caldwell (1976) associated increases in mental test performance over a 2½-year period with two environmental variables measured on the HOME. One of these was *maternal involvement with child*. Clarke-Stewart et al. (1979), in a study of randomly selected children, observed mother-infant interactions

under a variety of conditions, and conducted interviews and standardized assessments. They found that children's intelligence and competence across a wide domain was more closely associated with the mother's interactive behavior than with her IQ or socioeconomic status (SES). They found significant relationships between both the child's IQ and language capabilities and the mother's use of descriptive speech, positive play, nondirectiveness, and nonrestrictiveness. Field (1979) related language capabilities of high-risk infants at 2 years of age to earlier interaction variables when the infant was 4 months of age, including the infant's and the mother's attentiveness as well as the mother's imitativeness.

Cohen and Beckwith (1979) found a relationship between social interaction at 1 month of age and competence at 2 years of age that held for both preterm and term infants. The importance of parent-infant interaction variables seemed to *increase* over time. Beckwith and Cohen (1984) followed preterm infants to 5 years of age and reported that children who experienced *responsive* environments performed significantly better on measures of intelligence at age 5. Within the higher SES group, children who had experienced consistently responsive caregiving obtained an average Stanford-Binet IQ score of 114.5; children from the same SES background who had not experienced such caregiving obtained an average IQ score of 104.0.

These studies suggest that successful parent-infant interaction is an important contributor to the child's developmental outcome, and health professionals and hospitals should promote such relationships. Nonetheless, there are other variables that have important effects on later outcomes. VLBW infants are more frequently born to low SES mothers and thus are subject to a number of other risk factors, which may continue to influence the course of their development. These risk factors may interact, so the less healthy VLBW babies may be more vulnerable to the risks inherent within a deprived environment (Escalona, 1982). In the longitudinal research conducted by Beckwith and Cohen (1984), SES was increasingly related to test performance over the period from 2 to 5 years of age.

The research on later effects of parent-infant interaction has been largely correlational, which limits the conclusions that can be drawn about the direction of the observed effects. For example, Siegel (1984) noted that the developmental delays frequently observed in VLBW babies may cause unsatisfactory parent-infant interactions rather than vice versa. Furthermore, although correlations between early parent-infant interaction variables and later outcomes are sometimes statistically significant, they do not account for a large proportion of the variance in the research data—for example, 18% to 25% of the variance in Bayley scores (Beckwith and Cohen, 1980 and 1984).

One noncorrelational study by Barrera et al. (1986) looked at the impact of two types of home-based intervention on LBW infants' development: one directed towards improving the parent-infant interaction, and one towards

developmental stimulation of the infant. Although a number of variables improved with both types of intervention, the parent-infant interaction approach proved slightly superior.

Long-term follow-up has failed to show lasting significant differences between term and preterm infants (Kopp, 1983; Siegel, 1984). Furthermore, these findings have been questioned in one area that had generated a great deal of concern—the reported high risk for abuse among preterm and LBW infants. These findings have also been challenged on methodological grounds (Leventhal, 1981; Minde, 1980) because adequate controls were lacking in many of the studies.

A final issue regarding the effect of parent-infant interaction on outcome relates to the question of the overall weight that should be given to specific early experiences versus later or on-going ones. The recent interest in, and focus on, early parent-infant interaction has led to humanizing changes in hospital practices, and to other positive results. On the other hand, there are some negative aspects to this intense interest in early parent-infant relationships. Many professionals feel that failure to bond results in irreversible harm to the parent-infant relationship. This attitude can affect especially the parents of VLBW babies. A related issue is how significant very early experience is on the child's outcome. Professionals may become so interested in the importance of early experience that they may ignore the problems of continuing exposure to depriving environments or other significant, long-term influences. Beckwith and Cohen (1984) found that early circumstances contributed to outcome only when the experiences were maintained over time. Rutter (1980), who has studied maternal deprivation extensively, concludes that although there may be an early sensitive period for optimal socialization, later improvements in psychosocial circumstance *can* lead to social and behavioral improvement.

Breitmayer and Ramey (1986) followed term infants with optimal or nonoptimal conditions at birth to determine how important early risk factors were. Birth status was relevant only for those children who did not receive educational remediation. Among the children who received educational treatment, there were no differences based on birth status; later enriching experiences overcame the adverse effects of nonoptimal birth status. Although the subjects in this study were term infants, enriching experiences and stimulating environmental conditions also can be expected to improve the developmental outcome of preterm and VLBW infants.

Clarke and Clarke (1979) reviewed the findings on early social deprivation and suggested that there is no evidence that early experience is any more important than later experience. They concluded, "We believe that, in the present state of knowledge, the only safe assumption to make is that at least the first 15 or 16 years of life are critical."

Table 1

Studies of Parent-Infant Interaction in Preterm and VLBW Infants

KEY

PT = preterm
FT = full-term
BW = birth weight
GA = gestational age

x = mean
BSID IBR = Bayley Scales of Infant Development Infant Behavior Record
BNBAS = Brazelton Neonatal Behavioral Assessment Scale

NCAFS = Nursing Child Assessment Feeding Scale
S-B = Stanford-Binet Intelligence Scale
SES = Socioeconomic status
MLU = mean length of utterance

INVESTIGATORS	SUBJECTS	STUDIED	MEASURES	RESULTS AND CONCLUSIONS
Alfasi et al. (1985)	24 PT (x GA=35 wks; x BW=2175 gm) 39 FT (x BW=3387 gm) From inner-city hospital serving primarily low SES groups Mother's race: 29 Black 31 Hispanic 3 Caucasian	Feeding interactions in PT vs FT mother-infant dyads shortly after birth and at 1 month of age	NCAFS (Nursing Child Assessment Feeding Scale) Rating scale of mother's perception of her infant	Shortly after birth, PT infants and their mothers had lower interactive scores on the NCAFS than FT. Differences between infants remained significant at second observation, but mothers of PTs had improved so that there were no differences between the groups of mothers. Few differences across groups of mothers in perceptions of their infants.
Blake et al. (1975)	160 VLBW (All surviving VLBW infants from 1966-73 at UC Hospital in London)	Mother's adjustment after discharge Incidence of handicaps among infants at follow-up	Observation Standardized testing	Mothers of VLBW infants went through an emotional crisis after delivery, which did not resolve until they had the infant at home. All mothers except two eventually developed satisfactory relations with their infants. Incidence of major handicap: 10% Incidence of minor handicap: 20%
Brown & Bakeman (1977)	26 PT (x BW=1600 gm) 23 FT (x BW=3200 gm) Inner-city black population; excluded those with gross neurological damage	Differences in PTs behavior and how it affects mother-infant interaction Relationship of mother-infant interaction to outcome	Observation during feeding, prior to discharge, at 1 month and at 3 months HOME Inventory at 9 months	Mothers of PTs were more active at all feeding observations; maternal "persistence" during feeding was related (r = .37) to 9-month HOME variable of Maternal Emotional Involvement for PT but not FT.

Table 1 (continued)

INVESTIGATORS	SUBJECTS	STUDIED	MEASURES	RESULTS AND CONCLUSIONS
Cohen & Beckwith (1979)	50 PT (x GA=33 wks; x BW = 1852 gm) All English-speaking SES varied	Relationship between early interaction and later competence	Home observations at 1, 3, and 8 months post-conceptional age, including observation of feeding and (at 8 months) play Time-sampling of behavior Outcome: Gesell Scale (at 24 months); BSID (at 24 months)	Social-smiling behaviors at 1 month were effective predictors of development at age 2 years ($r = .54$ with Gesell; $r = .51$ with BSID). These results were even more consistent than relationships between 1-month interactions and 9-month outcome. Degree of variance accounted for is small.
Beckwith & Cohen (1984)	100 PT (GA=25-37 wks; BW=800-2500 gm) 62 from English-speaking families 28 from Spanish-speaking families 10 from "other" families SES ranged from lower to upper	Relationship between early interaction/home environment and later cognitive competence (measured at 4 and 9 months, and at 1, 2, and 5 years)	Home observations (as described above) Outcome: Measures described above plus Stanford-Binet Intelligence Scale (S-B)	Presents results for all measurement times and for both English- and Spanish-speaking samples. For English-speaking sample at age 5 years, the performance on S-B was consistent with standardization samples: (x IQ = 105.6, SD = 16.3). English-speaking sample was divided into families who consistently obtained high scores on interaction measures (1/3 of sample) vs those who received low scores on one or more occasions. Consistent responsiveness, apart from SES (although they were related), had positive effect on infant's outcome.

Table 2

Psychological Factors Affecting Maternal Behavior

INVESTIGATORS	SUBJECTS	STUDIED	MEASURES	RESULTS AND CONCLUSIONS
Affleck et al. (1985)	51 mothers of infants with serious perinatal problems or genetic condition associated with developmental disability (x GA=35 wks)	Mother's causal beliefs and relation to emotions and behavior	Interview one month after discharge or after diagnosis of genetic disorder HOME at 9 and 18 months Self-report of mood and care-taking problems	25% of mothers attributed cause of infant's disorder to maternal behavior; 22% attributed cause to others' behavior. Other-blaming mothers reported greater mood disturbance and more care-taking problems. Self-blaming mothers scored higher on 3 HOME subscales and Total. Authors suggest that self-blame is associated with more active coping efforts.
McGrade et al. (1985)	42 families with infants having problems listed under Affleck et al. above (x GA=34.9 wks) followed in home-based intervention program	Mother's early response to crisis of birth of infant with problems and later adaptation; examined whether early emotional expression predicted later coping	HOME at 9 months Ratings at 1 and 9 months of mother's use of intervention, coping skills, and mood Self-report of mood at 1 and 9 months	Mothers who expressed feelings ("ventilated") reported themselves as more confused. At 9 months, all mothers reported less mood disturbances than at 1 month. No relationship between ventilation or advice-seeking at 1 month and mother's functioning at 9 months.
Paludetto et al. (1981)	30 couples with babies in NICU in Naples, Italy. (x GA=33 wks; x BW=1707 gm) Excluded those with severe cerebral damage, malformations, or chromosomal disorders	Effects of increased access to NICU on parents' reaction to their baby	Interview with parents about 10 days after baby's admission to NICU	Found that many parents attributed cause for premature birth to obstetrical reasons; many experienced "unpleasant impression" upon first seeing their baby in NICU; almost all mothers had touched their babies and even fed them; fewer fathers had done so. Concluded that parents adapted well to access to NICU and that positive results (closer contact with baby) outweighed any negative results (e.g., anxiety about baby's frailty).
Stern & Hildebrandt (1984)	Study I: 225 college undergraduate volunteers Study II: 48 mothers of 3- to 18-month-old infants	Effects of "prematurity" label on adult perceptions of baby	Rating scales of videotaped infant labeled either "premature" or "full-term" and male or female	No effect for gender labeling. Infants labeled premature were rated as weaker, more shy, sadder, more passive, less fun, slower, less liked, quieter, and less smart. Authors note danger of self-fulfilling prophecy whereby parents may treat premature babies in such a way as to elicit the expected (but less desirable) behavior.

Table 2 (continued)

INVESTIGATORS	SUBJECTS	STUDIED	MEASURES	RESULTS AND CONCLUSIONS
Field (1977)	2 FT 12 high-risk PT (x GA=32 wks; respiratory distress syndrome) 12 postterm (x=16 days postterm)	Effect of separation and experimental manipulations on mother-infant interaction at 3½ months after expected date of delivery	Ratings of videotaped interactions when: interacted spontaneously; mother told to try to maintain infant's attention; mother told to imitate infant	Mothers of FT were less active than mothers of PT or postterm; separation *per se* was not a significant factor. Greater maternal activity was associated with less infant gaze ($r = -.39$). Instructing mother to imitate resulted in her becoming more contingently responsive to her infant.
Field (1979) (Only Study #3 reported here)	20 high-risk PT 20 FT Selected from larger sample of about 150 infants having the following characteristics: PT: x GA=32 wks; x BW=1600 gm; respiratory distress syndrome FT: x BW=3300 gm)	Effect of early interaction on later communication patterns	Play observation Ratings of interaction and coding of language	Correlation was found between both 4-month infant attentiveness and mother's imitativeness and infant's 2-year working vocabulary; mother's attentiveness to pauses at 4 months was related to larger MLU at 2 years of age.
Sigman & Parmelee (1979)	126 PT Infants All were GA<37 wks; BW<2500 gm 75 from English-speaking families	Contribution of perinatal variables and mother-infant interaction variables to outcome	11 measures of medical/neurological status and development (risk) Time-sampling of interactive behaviors at 1 and 8 months conceptional age Outcome: Gesell Scale (at 24 mos) BSID (at 25 mos)	Gesell x = 96.4; BSID Mental Scale x = 97.5. No statistical differences between outcome of low-risk vs high-risk infants until interaction variables were included in the risk determination; 1/3 of total outcome variance accounted for by these diagnostic measures.

Table 2 (continued)

INVESTIGATORS	SUBJECTS	STUDIED	MEASURES	RESULTS AND CONCLUSIONS
DiVitto and Goldberg (1979)	10 FT (x BW=3260 gm) 10 healthy PT (x GA=34.8 wks; x BW=1928 gm) 10 sick PT (x GA=30.3 wks; x BW=1531 gm) 10 infants of diabetic mothers (IDM; x GA=36.6 wks; x BW=3232 gm) All from intact families; predominantly white middle class	Compared parent-infant interaction across groups Assessed impact of neonatal behavior on the developing interaction	Feeding observation prior to discharge, at 10 days after discharge, and at 16 weeks of age (uncorrected age) BNBAS	Sick PTs were held at the greatest distance during feeding; they were less likely to be nestled or touched. Results ordered as follows for time held at distance: Sick PT IDM Healthy PT FT. These differences were not found at 16 weeks. More alert and responsive infants (on BNBAS) were more likely to be cuddled during feeding; less responsive babies were more likely to receive auditory and tactile stimulation during feeding. Few correlations were found with behaviors measured at 10 days; this suggests that this is a period of instability and adjustment for parent and infant.
Goldberg et al. (1980)	(Same as above)	(Same as above)	Feeding observation (as above) Floor-play observation at 8 and 12 months (uncorrected age) BNBAS and BSID IBR	At 8 months, sick PTs spent less time in play and smiling and spent the most time fretting; parents spent most time touching them and demonstrating toys. These differences had disappeared by 12 months. Those infants who were poor interactors in the neonatal period were later rated on IBR as having interactive deficits. Although many group differences decreased over time, PTs continued to be rated as less attentive and responsive at 12 months of age; not all of this could be accounted for by their relative immaturity.
Frodi and Thompson (1985)	20 PT (x BW=1990 gm) 20 FT (x BW=3506 gm) Middle class; excluded serious handicaps or illnesses	Differences between PT and FT, and between secure and insecure infants on affective expression and regulation	Ratings of videotaped interactions during a *strange situation* (involving mother, infant, and stranger) at age 11.5 months (corrected age)	No differences between PT and FT in security of attachment or affective expression and regulation. Different patterns of affective expression were found for secure and insecure infants.

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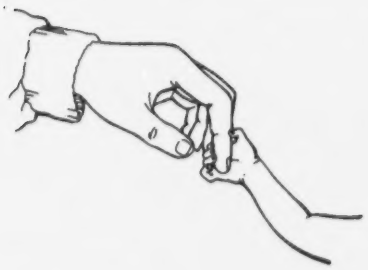

Medical and Developmental Management Concerns

A Changing Perspective: Early Intervention

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Abstract

The approach to developmental intervention in the special care nursery has undergone several changes over the past 25 years. This article provides a chronological study of the literature beginning with the research assumption that the NICU constitutes a source of sensory deprivation. It goes on to the study of neonatal units from an ecological perspective, with the current research emphasizing individualized developmental intervention. Research is reviewed and critiqued in order to provide the developmental caregiver with an enhanced knowledge base from which to work with parents and other health care team members to facilitate the infant's optimal development. Lastly, the article raises questions to promote further study.

Introduction

Recent advances in neonatal care have improved the chances for both survival and subsequent normal development of very low birth weight infants. As technology and medical intervention strategies ensure greater survival rates, researchers have become interested in understanding the effects that preterm birth and early medical complications have on infants. They have developed intervention strategies that lead to better neurological, behavioral, and developmental outcomes for these infants.

In the Neonatal Intensive Care Unit (NICU), the infant's immature nervous system is continually challenged by internal demands as well as by unavoidable interaction with the external environment of the hospital (Gorski et al., 1983). Research in environmental neonatology indicates that basic knowledge about the environment of the NICU and how it affects the preterm infant's health, growth, and development is necessary in order for health care

professionals to design the most appropriate and the most effective types of sensory intervention for the preterm infants in their care.

Over the past 20 years, several theoretical models of intervention with low birth weight infants have emerged in the literature. Initially there was concern that the preterm infant did not receive the same type of stimulation and experiences that a healthy term infant received. Based on this theory, hospitals developed programs to provide supplemental visual, auditory, tactile, and vestibular-kinesthetic stimulation (Gottfried, 1985).

Concurrently, researchers began to explore the effects of preterm birth on mother-infant attachment. Researchers developed new programs aimed at preventing faulty mother-infant bonding and helping mothers resolve the emotional issues surrounding the preterm delivery. As it has become more apparent that many low birth weight infants have deficiencies in their ability to elicit and sustain social interaction, newer intervention programs have sought to teach parents how to interact more effectively with their babies (Nurcombe et al., 1984).

Another approach since the mid-1970s views the NICU as excessively stimulating and the infant's immature nervous system as being bombarded by environmental stimuli that it is ill-equipped to modulate. Some investigators, such as Gorski et al. (1983), believe that excessive stress or demands from internal or external sources might threaten the recovery and growth of the infant at risk. This approach stresses the importance of assessing each infant's ability to cope with internal and environmental stimuli, and planning an intervention program that assists that infant in modulating these stimuli. This should promote appropriate adaptive responses. The remainder of this chapter explores these models of intervention to give the professionals working with preterm infants a foundation for understanding the complex needs of these infants and their families.

Supplemental Stimulation

As investigations in the fields of neonatology and child development began to indicate psychomotor deficits in very low birth weight infants, researchers and clinicians working in the NICUs began to question the role that the environment may play in both medical and developmental outcomes with this group of infants. Several investigators theorized that neonatal intensive care units provide an environment that is sensorially depriving for preterm infants (Korner et al., 1975; Lieb et al., 1980; Rice, 1977; Solkoff et al., 1969; White and LaBarba, 1976). More specifically, these investigators assumed that preterm infants are deprived in amount and/or pattern of various types of stimulation such as tactile, kinesthetic-proprioceptive, vestibular, visual, auditory, and socioemotional (Gottfried, 1985). Tactile, kinesthetic, and vestibular

stimulation are particularly important because they are the earliest sensory systems to develop. They also play an important role in cognitive, motor, and social-emotional development. Following is a review of studies by researchers exploring the effects of supplemental sensory stimulation on the preterm infant's growth and development.

TACTILE-KINESTHETIC STIMULATION

Studies of the effects of tactile-kinesthetic stimulation on preterm infants began in the 1960s. Although most of the research looks at the combined effect of tactile and kinesthetic input, two studies done by Solkoff et al. (1969) and Solkoff and Matuszak (1975) were designed to measure the effects of extra tactile stimulation. Both studies employed a design that involved the use of gentle rubbing or stroking as the type of extra stimulation given to the experimental group for a 10-day period. Findings of the 1969 study indicated that the handled infants gained weight more rapidly and were more active than the control infants. The experimental infants, at the end of 7 months, had higher developmental scores and had a more stimulating home environment. In the later 1975 study, the handled infants showed positive changes in alertness, response to environmental stimuli, motor development, and consolability. The researchers found virtually no difference in weight gain between the handled infants and the control group.

Those early studies are difficult to interpret because of the small sample size, which made statistical analysis of data impossible. The findings of both studies are tentative and only suggest possible trends. The research was unclear regarding whether the infants were moved at any time during the administration of the extra tactile stimulation. If the infants were moved, then the effects of the intervention probably should be attributed not only to tactile experiences but also to some form of proprioceptive-vestibular stimulation.

Later studies measuring the effects of combined tactile and kinesthetic stimulation attempted to overcome some of the methodological problems apparent in the earlier studies. White and LaBarba (1976) found that providing controlled amounts of daily stimulation over a 10-day period resulted in statistically significant differences in weight gain, in amount of formula taken, and in number of feedings required by the experimental and control groups. The stimulated infants gained weight at a greater rate over the 10-day treatment period than did the controls; they also ingested more formula at each feeding and required fewer feedings per day than did the controls. Although the experimental infants reportedly had greater formula intake, the examiners measured total volume of formula rather than caloric intake. In this study, controlled stimulation consisted of gentle rubbing of neck, shoulders, arms, legs, chest, and back, and gentle flexing of arms and legs for 15-minute periods every hour for four consecutive hours. Infants remained in their incubators during stimulation. The study did not outline the specific techniques used for passive stimulation and the position of infants during this

activity. The authors stated that although their investigation utilized a better research design than did previous studies, follow-up was not possible, due to sample characteristics of the preterm infants. Therefore the lasting effects of the treatment observed in this study cannot be determined.

Two other studies utilized similar methodology except for sample characteristics, frequency of stimulation, and outcome measures (Rausch, 1981; Scafidi et al., 1986). The types of stimulation used in these studies were very specific and consisted of gentle rubbing of various body parts and gentle passive flexion and extension of arms and legs. Both Rausch (1981) and Scafidi et al. (1986) reported greater weight gain in the treatment group at the end of the study period, although Rausch's findings were not statistically significant. In addition, the treatment group in Scafidi et al. showed increased motor activity, more alertness, and improved performance on the Brazelton Neonatal Behavioral Assessment Scale, specifically in the areas of habituation, orientation, motor response, and range-of-state behaviors. Field and her colleagues concluded that the changes and improvements evident in the treatment group might be a consequence of the tactile and kinesthetic stimulation. Scafidi's group also noted that the infants who received treatment were hospitalized six days less than the control infants after the onset of the treatment period. Neither study researched the long-term effects of the treatment procedures.

When examining the effects of combined tactile and kinesthetic treatment procedures on preterm infants following discharge from the NICU, Rice (1977) indicated that the experimental infants made significant gains in weight, in neurological development as assessed through the appearances of specific reflexes, and in mental development as assessed by using the Bayley Scales of Infant Development. Researchers trained the mothers of these infants to administer a specific tactile-kinesthetic treatment for 15 minutes four times a day for one month, beginning the day the infant arrived home. The study evaluated each infant at 4 months post-discharge. This test demonstrated that the infants had maintained their gains over a 9- to 11-week time period after treatment. Additional long-term effects were not measured.

All of the research cited suggests positive effects from the use of tactile and kinesthetic stimulation with preterm infants, but one should interpret these findings with caution. Three of the studies employed sample sizes of five or six in each group, which is considered small for statistical analysis. One study was done on infants post-discharge from the NICU, but the same principles and techniques may not apply to preterm infants still *in* the nursery. All the subjects in these research studies were considered medically stable; however, none of the investigators discussed their level of medical involvement.

Oehler (1985) further examined the issue of tactile stimulation. Three groups of medically stable preterm infants—a well group, a sick group, and a moderately ill group—were assessed on their responsiveness to auditory and

tactile stimuli. Results indicated that sick infants showed less hand-to-mouth motion (a stabilizing activity) and smiled less during all stimulus conditions. During talking, the sick infants showed more avoidance signals than the well infants, suggesting that even a mild stimulus elicited avoidance behaviors. They displayed the most avoidance during the combination of auditory and tactile stimulation, which suggests that the most adversive stimuli are combinations of two sensory modalities. The author stated that a small sample size in a study limits the significance of the findings; however, this study does suggest that immature infants can take only small amounts of stimulation and that an intervention procedure of touching preterm infants needs to be considered very carefully.

VESTIBULAR-PROPRIOCEPTIVE STIMULATION

Vestibular-proprioceptive stimulation is another specific type of activity that researchers have investigated for its possible beneficial effects on preterm infants. In a comprehensive review of the efficacy of vestibular stimulation, Ottenbacher and Petersen (1983) examined studies that employed this type of stimulation as the independent variable. They found 67 studies they thought would be relevant to the topic, but only 14 met the criteria established for the review. These articles investigated the effects of controlled vestibular-proprioceptive stimulation on the enhancement of development as defined by measures of cognitive, motor, or physiological functions. All the studies contained a pediatric population, some form of comparison or control group, and a detailed report of the results from statistical tests. The quantitative reviewing methods applied to the research revealed that vestibular stimulation facilitated the development of the children who received it. They performed significantly better than the children who did not receive the stimulation. Although the studies reviewed were done with a varied age range, several of the studies included preterm and term infants.

Further exploration of the efficacy of vestibular-proprioceptive stimulation and the upright position in bringing about behavioral changes in neonates was the purpose of the study conducted by Gregg et al. (1976). This study used 48 healthy term infants born to multiparous mothers. The researchers randomly assigned the infants to watch a moving visual stimulus while either in the horizontal or the upright position, with or without added vestibular stimulation and with or without pacifier sucking. The study assessed the completeness and smoothness of visual tracking behavior and the degree of eye opening for each visual stimulus excursion. The findings of the study were:

1. Infants who had been exposed to vestibular-proprioceptive stimulation by being moved either horizontally or semivertically engaged in significantly more efficient visual tracking than did infants who had not been moved.
2. Those infants who viewed the visual stimulus from a stationary upright position showed no difference in performance from those lying in a supine position. The authors concluded that it was not the upright position that

significantly influenced the infant's visual behavior. Instead it was the vestibular-proprioceptive stimulation that enhanced visual tracking behaviors in this group of neonates.

3. Sucking on the pacifier had as great an effect in enhancing visual behaviors as did vestibular-proprioceptive stimulation.

Although this study revealed important information in the area of neonatal development, no one has explored this type of vestibular-proprioceptive stimulation as a beneficial intervention technique with preterm infants. Further research, taking into account current principles of preterm infant development and levels of medical involvement for the babies being studied, may yield important information applicable to preterm infants in general.

In a well-controlled study, Korner and Thoman (1972) explored the soothing effects of contact and vestibular stimulation in healthy term infants. The subjects consisted of 40 infants equally divided between males and females who were breast- and bottle-fed. Each infant was randomly given six different interventions that replicated common maternal soothing techniques involving contact and vestibular proprioceptive stimulation. Crying time was measured both during and immediately following each intervention. The findings indicated that while contact reduced crying time in term infants, the vestibular-proprioceptive stimulation from being lifted and maintained in an upright position had a more powerful calming effect. The mode of feeding did not significantly affect the degree to which the infants were soothed. Previous early stimulation literature has stressed the importance of body contact and tactile stimulation in soothing infants (Bowlby, 1958; Harlow, 1958). However, Korner and Thoman's investigation into the soothing effects revealed something different. The ability of both contact and vestibular-proprioceptive stimulation to influence term infants' behavioral states suggests further exploration of its therapeutic effects with preterm infants.

In an attempt to provide preterm infants with stimulation that resembles the experiences in utero, researchers from Stanford University developed a gently oscillating waterbed (Korner et al., 1975). Although the researchers stress that the waterbed provides mainly vestibular-proprioceptive stimulation similar to that experienced by a fetus while floating in amniotic fluid, other forms of stimulation (tactile, for example) occur with the movement of the bed. Varying combinations of sensory experiences thus influence the findings. Preliminary studies by Korner et al., using the oscillating waterbed with preterm infants, assessed many areas of physiological functioning to determine if any detrimental effects resulted from the extra stimulation. When 10 preterm infants, ranging in gestational age from 27 to 34 weeks and weighing from 1050 to 1920 grams at birth, were compared to 11 control preterm infants of similar gestational age and weight, the waterbed stimulation did not have a harmful effect on the infants' vital signs, weight gain, or frequency of emesis. In fact, the preterm infants experienced less frequent apneic episodes. Apparently the decrease was a function of the extra stimulation. Korner et al.

(1978) investigated this particular finding by polygraphically recording the sleep and respiratory patterns of eight apneic preterm infants prior to, during, and after placement on the waterbeds. While the infants were on the oscillating waterbeds, apnea was reduced. This reduction was most consistent during indeterminate sleep and most pronounced during quiet sleep. These preliminary investigations of the effects of stimulation from a waterbed on preterm infants suggests that an intervention program that emphasizes vestibular-proprioceptive stimulation might be beneficial as a means of decreasing apneic episodes.

Other studies have examined different effects that waterbed stimulation has on preterm infants. In 1982, Korner et al. examined the benefits to sleep and motility that waterbeds might have with preterm infants who were receiving theophylline as a treatment for apnea. The results indicated that while on the gently oscillating waterbed, the treated infants experienced an increase in quiet and active sleep, shorter sleep latencies, fewer state changes, less restlessness during sleep, less waking activity, and fewer jittery and unsmooth movements. Lying on a waterbed, however, did not reduce residual apnea. A possible explanation given by the authors for their finding regarding apnea episodes (which was different from the first two studies) is that these infants required the use of protracted ventilator care and had more medical complications than the subjects of the previous studies. Finally, the authors concluded that the use of a gently oscillating waterbed may be particularly beneficial for those infants who are treated with theophylline for prolonged periods. They suggested this because infants who received the drug for long periods showed a significant reduction of wakefulness and state changes on the waterbed.

Another study by Korner et al. (1983) explored the effects of vestibular-proprioceptive stimulation provided by waterbed flotation on the neurobehavioral development of preterm infants. Their neurobehavioral development was measured by the Brazelton Neonatal Behavioral Assessment Scale. On orientation items, stimulated preterm infants attended and pursued animate and inanimate visual and auditory stimuli more like term infants than nonstimulated preterm infants. The experimental group also produced more mature spontaneous motor behavior that was smoother, more vigorous, and more moderate in speed, amplitude, and frequency than the control group's behavior. The intervention lessened the amount of irritability or hypertonicity the infants displayed and increased the amount of time they spent in a visually alert inactive state. These findings suggest that preterm infants receiving stimulation from waterbed flotation functioned more maturely and were more able to respond to the environment than infants not receiving stimulation.

Another area of infant health that has been studied is how the use of waterbed flotation affects growth. Kramer and Pierpont (1976) randomly assigned 20 preterm infants to either an experimental or control group and measured the effects of vestibular, proprioceptive, and auditory stimulation on specific areas of growth. The intervention program included placing the preterm infants on a

waterbed and mechanically rocking the waterbed one hour prior to each feeding. A taped, simulated heartbeat and a woman's voice played during the rocking period. The results of this study revealed significant weight gain, sizable increases in the biparietal diameter of the head, and behavioral improvement in nippling, feeding, and activity for the infants receiving stimulation compared to the control group. No differences in neurological and behavioral maturation, as assessed by the Dubowitz and Brazelton neonatal assessment scales, were found between the stimulated and the control infants. The authors conducted an additional analysis to compare the measurements of weight gain and head growth of the stimulated preterm infants to the expected fetal growth between 32 and 36 weeks gestation. The analysis revealed that the stimulated infants in this study had growth characteristics comparable to fetuses during the same gestational period.

According to the literature, the vestibular system has an important influence on cognitive, motor, and social-emotional development. Studies have shown that intervention involving vestibular and proprioceptive stimulation may have positive effects on various aspects of the preterm infant's growth and development. The investigators observed benefits in weight gain, sleep, behavior, feeding, visual skills, and motor development, and a reduction in apnea episodes. Careful attention to the methodological differences of these studies and the populations they investigated is important when evaluating the effectiveness of the stimulation and when generalizing the results to other preterm infant populations. Nonetheless, the research does indicate a need to continue the careful exploration of the individual preterm infant's ability to modulate and respond to vestibular and proprioceptive stimuli.

MULTIMODAL STIMULATION

In addition to Kramer and Pierpont (1976), two other studies have examined the different effects of multimodal stimulation on preterm infants. These studies compared cardiac and behavioral responses to tactual stimulation among three groups of infants: 30 term, 30 nonintervened preterm, and 30 intervened preterm. This study mainly investigated whether an intervention program involving primarily tactile, proprioceptive, and vestibular stimulation affected the preterm infants' sensory functioning during sleep. The intervened group received an average of 13 days of massage, positioning, rocking, and periodic visual contact and talking. Prior to discharge, tests measured each infant's cardiac and behavioral responses to tactile stimuli during active and quiet sleep. An electrocardiogram, to analyze heart rate acceleration and deceleration, and a 5-point rating scale analyzed changes in motor activity. The results showed that during active sleep, the term infants and the intervened preterm infants exhibited a significant cardiac acceleration to the tactile stimulus; the nonintervened group failed to respond significantly. Regarding behavioral responses during active sleep, the term infants were most responsive and the nonintervened preterm infants least responsive; the intervened preterm infants closely approximated the responses of the term

infants. In quiet sleep, the intervened and nonintervened preterm infants showed similar behavioral responses, both significantly less than the term infants. Since both the term and intervened preterm group gave significant cardiac responses to the stimulus during active sleep, Rose et al. (1980) hypothesized that intervention narrows the gap between these two groups to some extent. Although this study measured only one aspect of sensory processing under a specific condition (sleep), it does provide some experimental support for the idea that sensory enrichment can improve sensory functioning in preterm infants.

Investigation by Lieb et al. (1980) into the immediate and long-term effects of multimodal sensory stimulation on preterm infant development suggests a positive relationship. The design of this study was different from the ones used in previous intervention research; in this study the first 14 infants who met the selection criteria were assigned to the control group. The prescribed intervention program was designed according to the level of infant care and involved either a combination of visual and tactile stimulation or a combination of visual, tactile, kinesthetic, and auditory stimulation. The investigators administered the Brazelton Neonatal Assessment Scale to the control and treatment groups both immediately prior to treatment and just before discharge from the NICU. In addition, they performed a developmental assessment using the Bayley Scales of Infant Development at six months past the expected date of confinement. Pre- and post-treatment comparisons of the neonatal assessment results showed that the treated infants performed significantly better than the control infants on interactive processes. However, both groups demonstrated similar functioning on motoric and organizational processes. The results of the 6-month developmental assessment showed that the treated infants had significantly higher developmental status than the control infants on both the mental and motor scales. The authors concluded that a systematic approach to intervention with preterm infants seems important for achieving higher levels of developmental functioning. However, questions still exist concerning the optimal type of intervention, its duration, and the proper amount of stimulation. Researchers might also explore the issue of whether there exist specific critical periods for intervention.

In summary, although all of the supplemental stimulation research cited suggests positive effects of intervention on various aspects of the preterm infant's growth and development, one must be cautious in interpreting these findings. Other critiques of this research have stressed the importance of evaluating the methodological and research design limitations when interpreting the results and generalizing the information to other preterm infant populations (Cornell and Gottfried, 1976; Gottfried, 1985). Other investigators have raised additional questions regarding the individuality of the preterm infant's medical stability and neurological and behavioral development, and the long-term effectiveness of intervention (Oehler, 1985; Gorski et al., 1983; Gottfried, 1985). What researchers do seem to agree on is that the early environment of the preterm infant is different from that of the

healthy term infant. Future research needs to explore the ecology of the NICU and the individual preterm infant's ability to modulate and respond to environmental stimuli. Current research that begins to explore and clarify these questions and concerns is discussed later in this chapter.

Mother-Infant Interaction

Studies have also attempted to determine the effects of mother-infant interaction on the development of low birth weight infants. Powell (1974) tested the following hypotheses:

- Increased handling of low birth weight infants would result in increased weight gain and increased developmental quotients for the babies.
- Increased maternal handling would result in a positive difference in maternal behavior.

There were 36 preterm infants divided into three groups: the maternal experimental group; the handled experimental group; and the control group. In the first group, the researchers encouraged each maternal figure to visit and handle a specific baby in the nursery as often and as long as she liked. The amount and type of handling varied according to the infant's condition and the maternal figure's experience. The second group, the handled infants, received extra handling by either the examiner or one of two licensed practical nurses throughout their stay in the nursery. The type of handling depended on the infant's condition, but the amount in terms of length of time (20 minutes) was consistent for each infant. The findings suggest a positive, but not significant, relationship between extra stimulation and the infant's ability to regain birth weight. No differences were found in long-term weight gain at 2, 4, or 6 months of age. The study found that the infants who were given extra stimulation (a combination of the maternal and handled groups) had significantly higher scores on the Bayley Mental and Motor Scales at 4 months corrected age than the controls, who did not receive extra handling. In addition, the handled groups had significantly higher scores on previously selected items from the Bayley Infant Behavior Records. When the maternal group was compared with the other two groups, the data did not show a significant relationship between maternal involvement and positive differences in maternal behavior or infant development (Powell, 1974). When interpreting these findings, certain factors need to be considered. The small sample size limits the significance of the results, and the amount and type of stimulation was not controlled across the three groups, thus increasing the variables affecting data analysis and making the results difficult to interpret.

Based on the assumption that infants as well as mothers influence the kinds of interaction established between them, Brown et al. (1980) studied 41 healthy preterm infants and their socially disadvantaged mothers. The researchers

randomly assigned mother-infant dyads to one of three groups: an infant stimulation group, a mother training group, and a "both" group in which infants received stimulation and mothers received training to help them become more responsive to cues from their babies. In addition, a fourth group of preterm infants received routine nursery care and served as the control group. Stimulation consisted of periods of tactile, vestibular, auditory, and visual stimulation. The results indicated that the four groups did not differ at time of discharge in performance on the Brazelton Neonatal Scale, in weight gain, or in length of hospital stay. Mother training appeared to have increased the number of visits mothers made to their infants, but only while the mothers were still under hospital care. The groups did not differ on any other measures of mother-infant interaction. The first three groups were compared at 9 and 12 months with respect to mother-infant interaction and infant development; the researchers noted no apparent group differences. The authors stated that the mother group could actually be considered a "no treatment" group due to the lack of mother involvement once the mother was discharged from the hospital. Several possible explanations for the lack of involvement suggested by the authors included transportation difficulties, cultural beliefs, fear of their infants, and other personal crises such as lack of financial support and inadequate or no housing. In summary, this study failed to demonstrate either short-term or long-term effects of nursery-based intervention programs on infant development or mother-infant interaction.

Another study done by Nurcombe et al. (1984) explored the effects of an intervention program designed to teach the mothers of preterm infants to be more sensitive and responsive to their infants' physiological and social cues. It

This baby appears overstimulated.

was predicted that improved mother-infant interaction would facilitate infant development and improve maternal adjustment. There were 34 preterm infants randomly assigned to an experimental intervention group in which the mothers received special training. Two randomly assigned control groups, whose mothers received no special training, consisted of 40 preterm infants and 41 term infants. Inspection of the data revealed that the mothers of the intervention group were more satisfied with, more confident in, and more favorable toward child-rearing than the mothers of the preterm control group. A comparison between the mothers of the term infants and the mothers of the preterm infants showed that the mothers of term infants appeared to be more confident in and more favorable toward child rearing, but did not appear to be more satisfied with the maternal role. No significant differences between the two preterm groups at 6 months adjusted developmental age were noted in infant cognitive development or maternal psychopathology.

Although the results of these studies vary, it is interesting to note that the intervention program designed to help mothers understand and respond to their infants' physiological and social cues appeared to have a positive effect on mother-infant interaction. A possible explanation could be that the mothers' selection of appropriate interactive tasks promoted a meaningful and purposeful response from their infants, which in turn reinforced the parents' actions and encouraged further mother-infant interaction.

NICU Sensory Equipment

In the late 1970s investigators began looking at the possibility that a variety of stimuli could have a negative impact on the fragile preterm infant. One group of investigators examined auditory input, in which they measured sound pressure levels (SPL) in the NICU itself, inside isolettes, and inside transport incubators (Shenai, 1977; Bess et al., 1979; Long et al., 1980). Bess et al. reported on SPL, averaged over three trials in seven individual isolettes equipped with life support systems. They also investigated the impulse noise created by striking the side of an incubator. The researchers found that the life support equipment added 15-20 decibels (dB) in high-frequency acoustic energy; this brought the isolette's ambient noise level up to approximately 81 dB. Striking the side of the isolette, such as when closing the side portals or putting a chart into the isolette, produced SPL ranges of 130-140 dB. They reported that these high-frequency noises were more damaging to the immature cochlea than low-frequency noises would be. Associated issues that need investigation according to Bess's group are the questions of the effects of noise and ototoxic drugs as well as the overall lack of information regarding the effects of noise on preterm and sick newborns.

Sound pressure levels in transport incubators were even higher during transport. The lowest transport sound levels were 90 dB, compared to the

nursery SPL of 60-70 dB (Shenai, 1977). The author's findings are important, particularly when viewed in relation to the fragile medical state of many infants at the time of transport.

Long et al. (1983) made five continuous baseline recordings of three-hour duration over a week's period of time in their NICU. They then met with the nursing staff to determine what the staff perceived to be the cause of the excessive noise noted on their recordings. Based on staff feedback, the researchers silenced cardiac monitors, removed a capillary tube centrifuge from the NICU, and muffled the telephone. They made a new set of sound tracings after these modifications. The new tracings showed that while there was a slightly lower baseline of noise in the unit, periodic loud noises continued to occur with the same frequency and SPL. Staff activity caused all the high-amplitude SPL: shutting doors, closing diaper pails, laughing, disposing of trash, and holding conversations. In addition, over a two-hour period researchers monitored the impact of sound levels on two infants, measuring their heart rate, respiration rate, transcutaneous oxygen tension ($TcPO_2$), and intracranial pressure (ICP). Loud noises penetrated the isolette. A total of nine sudden noise incidents were noted during the four hours of observation. Six of the nine events were followed by a fall in the infants' $TcPO_2$ and a rise in their ICP. All nine events were followed by increases in the infants' heart and respiratory rates. In each of these findings, the investigators hypothesized that sudden loud noise may lead to infant hypoxemia. This hypothesis was based on information regarding the effects of noise such as that measured in the NICU. Studies by Gädeke et al. (1969) and Gabriel et al. (1976) found that those types of noise levels alter sleep states and bring about more active rather than deep sleep. Apnea occurs more frequently during active sleep and can lead to hypoxemia. The authors recommended decreasing staff-related noise as well as equipment noise by sensitizing the staff to the amount of noise they make.

The effect of handling on an infant's oxygenation is another area of investigation. Speidel (1978) reported on falling arterial oxygen tension (PaO_2) levels in a 33-week gestation infant at 1½ hours of age. PaO_2 levels fell during routine medical procedures such as blood drawing for capillary blood gases, temperature taking, IV placement, lifting the infant for an X-ray plate, and changing sheets. It appeared that handling the infant for any reason resulted in a fall in PaO_2. Speidel noted that the infant spontaneously recovered from this PaO_2 drop. However, when a series of procedures were performed on the infant, the PaO_2 remained low for a longer period of time. While primarily anecdotal, this report questioned the validity of subjecting the infants to NICU routines at the risk of ensuing hypoxia. It was suggested that the staff reconsider routine procedures for every infant.

Long et al. (1980) were more rigorous in their measuring of the effect of handling premature newborns. They used $TcPO_2$ monitoring on low birth weight infants. There were 30 infants randomly assigned half to an

experimental group and half to a control group. For each of the 30 infants, continuous recordings of heart rate, respiratory rate, and $TcPO_2$ were made for 4 hours a day for the first 5 days after birth. All nursing personnel for the control group used conventional methods and were blind to the $TcPO_2$ measurements. Those members of the staff caring for the experimental group were instructed in the use of the $TcPO_2$ monitor and used it to modify the timing and type of procedures to maintain the infants' oxygenation in an optimal range. Infants in the experimental group had significantly fewer periods of unacceptably low oxygenation than those in the control group. The infants in the control group were handled more often and experienced more hypoxemia. This may have been because the staff caring for the control group did not receive the $TcPO_2$ monitor feedback. Thus, they were not as able to identify poor oxygen saturation as the staff caring for the experimental group could. With this information, they could have modified their handling to help the infants become more stable. The findings of Long et al. supported Speidel's findings that nursing routines need to be re-evaluated and unnecessary handling of infants eliminated.

The Ecology of the NICU

A new view of the NICU's sensory environment began in the middle 1970s. Cornell and Gottfried (1976) reviewed the literature regarding supplemental sensory stimulation for premature and sick newborns and found a variety of problems with this approach. They reviewed hospital-based studies in which all interventions were based on the assumption that the infant in the NICU was sensorially deprived. Yet in their review they did not find systematic data that supported that premise. There were also methodological problems with these stimulation studies: varying insult/medical variables, unclear methods of randomization of subjects, and little attention paid to the possibility of differential dropout during outpatient follow-up.

Cornell and Gottfried reminded the reader of the problems of assuming that a "more of something" intervention approach can only be advantageous by citing the relationship between oxygen administration and retrolental fibroplasia. They asserted that studies should look for both benefits and side effects of stimulation, and they must clarify the goals of the intervention program. However, the authors stated that, even before implementing an intervention program, the ecology of the premature infant must be documented through observation and recording of typical nursery events and the ways they interrelate with each other as well as with the infants' behavior. These authors felt it was critical to determine infant sensory thresholds and processing capabilities. They suggested that documenting the special-care nursery ecology may even lead to interventions that would decrease the environmental stimulation rather than increase it.

There have been several descriptive studies since the review of intervention programs by Cornell and Gottfried that have attempted to document typical nursery events and their effect on an infant's responses. Lawson et al. (1977) used a time-sampling methodology to describe NICU events. They measured speech and nonspeech sounds, handling, illumination levels, and sound pressure levels. They found that instead of living with sensory deprivation, the premature infant is in fact exposed to a great deal of stimulation occurring in distinctive patterns. Gaiter et al. (1981) used a continuous interval (60-minute) observation/recording scheme to differentiate the nursery environment by major categories of stimulation, to look at sequences of events, and to measure patterns of change in stimulation over different intensive/intermediate convalescent levels of care. Their results indicated that the overall frequency of handling in the different levels of care did not differ. Staff and parent handling of the infants was not related to the infants' degree of illness. Infants were spoken to at equal rates over the days and nights, but in general, caregiver social interactions with the infants were infrequent.

Gottfried et al. (1981) performed one-minute observations every hour for 24 hours over three nonconsecutive days. These measurements were in intensive care and convalescent care nurseries. Observers recorded social and nonsocial handling/input and found little diurnal variation in lighting or other aspects of care. Sound levels were at 70-80 dB, which is the equivalent of light auto traffic. Both visual and auditory stimulation were present continuously. It was noted that co-occurrence of social events with any visual, auditory, and tactile input was infrequent.

One drawback to these studies is that they described events for only short time periods. They did not describe how long various interventions and subsequent infant responses last. Gorski et al. (1983) dealt with this issue when assessing infant responses to chest physical therapy and close social interaction. They observed a preterm infant two times per week for six-hour sessions for a three-week period. Observers recorded specific behavioral and physiologic indices. These were time-synchronized with a cart-mounted microcomputer data collection system that measured $TcPO_2$, heart rate, and respiratory rate. The researchers analyzed infant behavioral and psychologic distress based on 5,198 observations of caregiver/infant interaction. This study found that subtle and gross distress signs occurred significantly more frequently within five minutes after chest PT and close social interaction when compared with baseline measures of incidence of infant distress. These longer-term observations emphasized that infant reactions to a stressful event may not always immediately follow that event.

In 1981, Gottfried et al. published the results of their analysis of caregiver contacts with premature infants that occurred over a continuous 24-hour period across two nonconsecutive days. Infants in intensive care had more frequent brief caregiver contacts than did infants in convalescent care. This did not differ from shift to shift, nor from day to night. Contacts were usually

oriented to medical-nursing activities. Social interaction occurred only as a part of routine care. Rarely was the sole aim of contact to provide social input to the infant. There were few opportunities for infants to experience what Gottfried termed "integration of social sensory experiences." Soothing took the form of talking, but seldom was there any touching or a combination of talking and touching. Commonly, caregivers handled newborns but did not talk to them. They often positioned the infants in such a way that the babies could not see who was touching them. The social input they provided often was independent of the infant's behavioral state.

Linn et al. (1985) described the ecology of their NICU with the goal of documenting frequency, duration, and sequence of events during eight daytime hours. This descriptive information confirmed much of what had already been reported: compared to the home environment, the NICU illumination levels were higher, there was more background adult speech, and there was little contingency-based provision of tactile, vestibular, and social input to the infant. By examining sequences of events, Linn's group was able to examine more closely nurse-infant contingent responsiveness. It appeared that nurses socially responded to infants who vocalized or visually attended to the nurse. However, the infants rarely were able to sustain an awake state and interact in that manner. An analysis of the sequences of NICU events also confirmed what researchers had seen empirically in many instances prior to this: The preterm infant's day runs on the nursery schedule imposed by adults regardless of the infant's state of arousal and readiness for interaction, feeding, or medical procedures.

The Preterm Infant's Capabilities

While many investigators were reporting on the ecology of the NICU, others were describing the preterm infant's capabilities and needs (Als et al., 1979; Als, 1983). They characterized the infant as an organism that is not yet fully adapted to extrauterine life, not only in terms of respiration and thermoregulation but also in the infant's ability to modulate and cope with the environment's sensory input. The infant's motor system may not yet be ready to be controlled smoothly in the face of gravity and unrestricted space. Als et al. (1979) stressed the importance of linking an infant's level of behavioral and psychologic organization with individualized intervention. They considered this approach more appropriate than one that assumes that the preterm infant is a deficient term baby who needs to be trained in term behaviors.

In examining premature infant behavior, Dr. Als and her associates developed the "Synactive Theory" of development (Als et al., 1982; Als, 1983). It is based on the principle of *synaction*, the simultaneous development of specific subsystems as they interact with each other and with the environment.

These subsystems are organized hierarchically and are intended to reflect stages of very early behavioral organization.

1. The infant's primary need is to stabilize and integrate the autonomic functions of respiration, heart rate, temperature control, and digestive and elimination functions. External tactile, vestibular, or auditory input may overwhelm the balance of these functions.
2. The infant's motor system continues to mature. Movements and active postural adjustments may infringe on stage one, possibly causing psychologic instability with resultant apnea and bradycardia.
3. The infant shows emerging differentiated states of sleep, waking, and crying. The infant's attempts to remain in the alert state may impinge on earlier motor and psychologic stability.
4. The infant is able to maintain an alert state and is available for interaction. Prolonged attentional and interactive demands may disrupt state, motor, and autonomic balance.

The infant attempts to regulate responses to varying environmental demands so as to maintain equilibrium among these differing subsystems. Als et al. (1982) catalogued infant behaviors that they view as indicators of the infant's self-regulatory attempts. The terms for these behaviors are "avoidance/withdrawal" behaviors and "approach/groping" behaviors. The infant moves toward stimulation that is appropriate in terms of its complexity, intensity, and timing, and moves away from input that is inappropriate for its level of function/subsystem balance. It is through these behaviors that the caregiver can identify situations that are either stressful or organizing for the infant. Examples of avoidance behaviors are gaze aversion, gagging, or yawning, while examples of approach behaviors are tucking into flexion, bringing hand to mouth, and hand/foot clasping.

The lines of investigation regarding special care nursery ecology and infant capabilities have recently met in the literature. Several investigators are now looking at how these concepts interrelate and how caregivers can support the infant's emerging capabilities rather than try to convert a preterm infant into one more like a term baby.

Preliminary findings of research conducted by Gorski (1983) reveals a new direction that many intervention studies are taking. Gorski observed psychologic and behavioral factors in infants with chronic lung disease for two 8-hour sessions. Some infants used approach and avoidance behaviors in response to naturally occurring environmental events. After analysis of the data, he developed caregiving strategies for infants in the experimental group that were carried out for two weeks by trained nursing staff. Control group infants continued to receive the regular nursing care. Early results suggested that there were changes in infant sleep/wake patterns, and in quality of movement. There was also improved psychologic stability in the experimental group. Gorski also reported two case studies. One infant showed a decrease in

bradycardic episodes when given rests lasting at least 10-15 minutes between caregiving procedures. Another infant who usually vomited after feedings showed less of this behavior and improved weight gain when caregivers responded appropriately to the infant's cues.

In their ecologic study of the NICU, Linn et al. (1985) described infant responses to caregiving and other environmental occurrences as part of examining sequences of events. They concluded that the sensory input of the nursery was sometimes overstimulating and sometimes depriving. Individual infant responses showed that babies reacted to these changing levels in the nursery with a variety of responses and levels of arousal/disorganization. These authors considered it inappropriate and inaccurate to label the NICU as either overstimulating or sensorially depriving. There is no blanket statement regarding how an infant copes while in the NICU.

Als et al. (1986) developed a behavior observation protocol that describes specific patterns of stress and self-regulatory behaviors. Along with heart rate, respiratory rate, and $TcPO_2$ readings, they collected behavioral information before, during, and after routine caregiving procedures on eight control and eight experimental infants. They selected these infants based on several physical factors that made them high risk for chronic lung disease. The two groups were comparable on medical and demographic variables. Based on the assessment, they provided individualized caregiving activities that support well-organized function in terms of the synactive theory for the experimental group only. The research article describes the activities in detail. The researchers designed these activities to support infant self-regulation and decrease stress. The infants in the experimental group stayed on a ventilator and supplemental oxygen for significantly fewer days. These infants were also fed completely by bottle or breast earlier than control infants. Developmental/behavioral assessment scores at 1 month, 3 months, 6 months, and 9 months post-discharge were higher for the intervention infants than for the control group. Als and her group concluded that very low birth weight preterm infants profit significantly medically and developmentally from individualized developmental/behavioral care in the NICU. Currently they are continuing along these lines of investigation, looking at larger groups of infants who have received this type of individualized intervention.

Summary

The approach to developmental intervention in the special care nursery has undergone several changes over the past 25 years. Earlier research was primarily based on the assumption that the NICU constituted a source of sensory *deprivation* during a critical period of an infant's growth and development. Intervention consisted of providing routine packages of sensory stimulation that attempted to compensate for this perceived lack in the NICU

environment. Several investigators have questioned these studies and their approach to intervention, particularly in terms of methodology and research design (Cornell and Gottfried, 1976; Gottfried, 1985; Newman, 1981). Although these earlier sensory stimulation studies did begin to provide an understanding that the environment of the high-risk infant is different from that experienced by the healthy term infant, they neglected to assess the ecology of the preterm infant prior to intervention. In addition, they made no attempt to assess individual differences in sensory thresholds and thus did not match stimulation levels appropriately. Results of the early sensory stimulation research were reported in terms of the mean outcome for the control and experimental groups. Beneficial effects for a group does not eliminate the possibility of harmful effects for an individual infant.

More recently, researchers have studied neonatal units from an ecological perspective. These units are at times *over-stimulating* to the ill or preterm infant. Infants in these units are often exposed to inappropriate patterns of animate and inanimate stimulation. This input is frequently unrelated to an infant's state of arousal or readiness.

Research and clinical practice literature reveal that intervention is now aimed at assessing each individual infant's capabilities and then determining appropriate inhibitory as well as excitatory input. Preterm infants are not merely incomplete term infants. The preterm infant's early birth has triggered physiologic processes that are not yet adapted or developed for the environment outside the womb. These infants show coping or self-regulatory behaviors that help them maintain their own physiologic, motor, state, and attentional system equilibrium in the face of a myriad of environmental demands. These behaviors also serve to alert the sensitive, informed caretaker regarding the infant's needs.

As Als et al. (1979) emphasized, the behavior of the infant is the primary route of communication. Caregivers must become aware of the infant's behavior repertoire. The infant may show signs of any of the following: lowered sensory thresholds, overtaxing demands of the physical and social environment, efforts to regain physiologic balance, and distressing effects of disorganized motor activity. The caregiver should respect the infant's attempts to both attend to stimulation and to dampen or tune it out.

Individualized developmental intervention assumes that the caregiver will assess the infant and its environment. Such an evaluation includes unobtrusively observing the ongoing interaction between the infant and the animate/inanimate environment. The assessment notes the overall efficiency of the infant's functions: the physiologic and motoric state, and the interactive systems. Only after gathering this information can the caregiver determine which interventions will promote behaviors appropriate to the infant's gestational age. The goal of appropriate intervention is to balance protection and arousal.

This article has focused on the caregiving staff's differing approaches to an infant's sensory stimulation. However, developmental intervention in the Special Care Nursery must also always involve the family. The caregiver assesses the infant's current status and shares this information with the parents. Through helping the parents understand their infant's behavioral cues and the reasons for protecting the infant from the taxing effects of inappropriate stimulation, the caregiver helps facilitate the emerging reciprocal communication between parent and infant that promotes attachment (Gorski, 1983).

An alert baby invites interaction.

The transition from hospital to home brings about a series of changes for both parent and infant. The infant must adapt to the differences in the environment and in the daily routine. During this adaptation process, the infant's behaviors may change. Specific handling techniques that once worked in the hospital may no longer be successful. The parents, as they move from the role of visitor to full-time parent assuming full responsibility for meeting the infant's needs, may feel a loss of their sense of predictability regarding their infant's behaviors at a time when they feel they need it most (Sammons and Lewis, 1985). The developmental caregiver may be able to ease the transition from care unit to home by guiding the parents in getting to know their infant, and by encouraging observation and interpretation of the baby's particular behavioral signals. Understanding the general process of the transition from hospital to home and their infant's coping abilities may empower parents to continue to get to know their infant and to adapt successfully their responses to the baby's changing behaviors. The developmental caregiver's shift from a primarily infant-centered care approach to a family-centered approach should ease the transition to home as well as prepare the family for interaction with follow-up

services. Family-centered care is mandated in the Education of the Handicapped Act Amendments of 1986, Public Law 99-457. Part H of this law emphasizes the essential role of families in facilitating the growth and development of their children with special needs. The NICU seems to be an appropriate arena to begin family-centered care.

Many questions regarding developmental intervention remain.

- Which activities most fully enhance infant behavioral organization?
- What is the best timing of handling the infant with respect to psychologic stability and sleep/wake cycles?
- What is the best way to enhance the infant's arousal states?
- With very young preterm or sick infants, is protection from the environment the only goal?

The professional providing developmental intervention needs to keep all these questions in mind while working with parents and other health care team members to facilitate the infant's optimal development.

Definition of Terms

Adaptive Responses: Behaviors that reflect the growth and maturation of the nervous system in response to environmental demands, leading to increased competence. The process of organizing the response as well as feedback from the development of the nervous system.

Contingent Behavior:s Those behaviors that depend upon a specific stimulus.

Ecology: The relations between an organism and its environment.

Extension: The action of straightening the neck, back, arms, or legs.

Flexion: The act of bending or pulling in a part of the body.

Handling: Holding, positioning, diapering, bathing, or any other medical-nursing procedure.

Hypoxemia: Insufficient oxygenation of the blood.

Kinesthetic: The conscious perception of muscular motion, weight, and position.

Modulation: The brain's regulation of its own activity. Modulation involves facilitating some neural messages to produce more of a perception or response, and inhibiting other messages to reduce excess or extraneous activity.

Multiparous: Having given birth at least once before.

Neurobehavioral Organization: Gestational-age-dependent neurophysiologic and behavioral processes functioning in equilibrium.

Ototoxic: Having a deleterious effect upon the organs of hearing and balance.

Physiologic Stability: Stable autonomic processes such as heart rate, respiratory rate, and thermoregulation.

Proprioception: The sensations from the muscles and joints. Proprioceptive input tells the brain when and how the muscles are contracting or stretching, and when and how the joints are bending, extending, or being pulled or compressed. This information enables the brain to know where each part of the body is and how it is moving.

Self-Regulation: The infant's attempts at attaining neurobehavioral organization.

Sensory Stimulation: The application of specific types of sensory input.

Tactile: Pertaining to the sense of touch on the skin.

Vestibular: Sensations from any change in the position of the head in relation to gravity and accelerated or decelerated movement.

Visual: Pertaining to the sense of sight.

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Intracranial Hemorrhage

by Caryl J. Semmler, Ph.D., O.T.R.

Abstract

Intracranial hemorrhage is a primary cause of death in VLBW neonates and is the most important adverse neurologic event of the newborn. Because of problems in diagnosing, classifying, documenting, treating, and monitoring intracranial hemorrhage, information on incidence and outcome varies.

Intraventricular/periventricular hemorrhage is a major cause of death in VLBW neonates and appears to be a contributor to the poor outcome of some survivors. About one-third to one-half of VLBW neonates will have intracranial hemorrhage in the neonatal period; the incidence is higher with lower birth weight and gestational age. Most at-risk infants receive a diagnosis by ultrasound by 3 days of age. A considerable percentage of these infants show hemorrhages within a few hours after birth. Because reasonably accurate diagnosis of hemorrhage has generally been available only since about 1980, investigators have accumulated little information on developmental outcome. Studies suggest that infants with the milder grades of hemorrhage may have outcomes similar to VLBW infants without hemorrhages.

Infants with more severe hemorrhages that extend into the parenchyma appear to have a greater incidence of porencephaly, seizures, cerebral palsy, retinopathy of prematurity, and cognitive and speech delays. Research has indicated wide individual variance of outcome, ranging from profound damage to apparently normal functioning. Infants with periventricular leukomalacia (degeneration of the white matter around the cerebral ventricles) seem to be especially associated with cerebral palsy. During the first few days of life, the major concern regarding intracranial hemorrhage is whether it is life-threatening, and whether posthemorrhagic hydrocephalus will develop. By the time the infant is discharged from the hospital, the major concerns are developmental outcome and the impact on the family.

Recommendations

1. While the neonate is in the nursery, caregivers should avoid unnecessary activities or procedures during the first weeks that may cause fluctuations in the infant's intracranial pressure. Intracranial pressure fluctuations appear to be a contributing mechanism in intracranial hemorrhage. (Research is needed to rule out position changes and excessive handling as contributors to ICH.)

2. The parents or guardians of infants who have had hemorrhages should receive information on the probability of problems that may occur. They should know the general types of problems that go along with the extent of hemorrhage their child has experienced. This should alert parents to the need for monitoring their child's health and development.

3. Caregivers should learn the severity (classification) and location of the intracranial hemorrhages in children being followed. If follow-up services are limited, the major services can be provided to those of highest risk first. Knowing the ICH grade provides additional information regarding anticipated health and education needs.

4. Follow-up health care providers should monitor the children for ventricular dilatation and posthemorrhagic hydrocephalus (PHH), and refer to neurologists or neurosurgeons as indicated. Early identification of ventricular dilatation of PHH may help prevent further brain damage, if appropriate treatment measures are implemented.

5. Monitoring for seizures, retinopathy of prematurity, and visual impairment is especially important in children with Grade III and IV hemorrhages. Children who have experienced severe hemorrhages are more likely to have multiple health problems.

6. All children with Grade III and IV hemorrhages should receive frequent developmental assessments during the first year, such as at 3, 6, 9 and 12 months. These children are at extreme risk for developmental delay and/or cerebral palsy, and may benefit from early developmental intervention. Timely identification of developmental problems allows for prompt referral for intervention.

7. Children with Grade III and IV hemorrhages who show hypertonia, or children with other ICH grades who show contractures or delayed motor development for adjusted age, should be referred for physical or occupational therapy. These children are probably at highest risk for permanent neurological sequelae (as opposed to the approximately 40% who show transient neurological signs). Therapists can provide instruction on exercises and appropriate motor development and feeding activities.

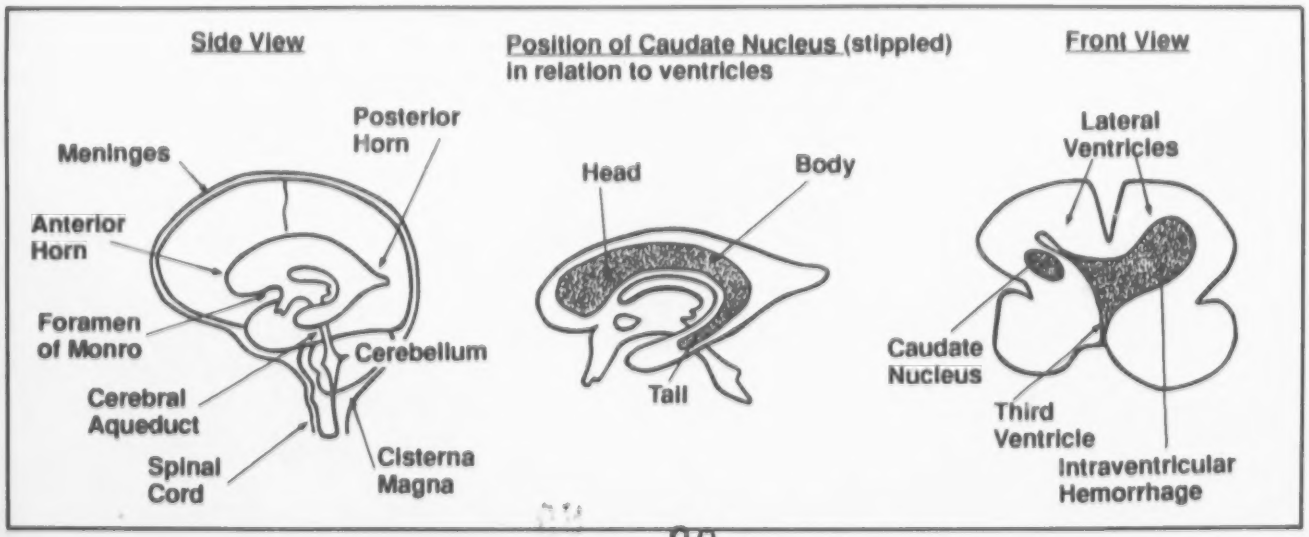
8. Parents of children with substantial handicaps should be referred to social services for exploration of financial supplemental programs, such as the State Crippled Children's Services, and for assistance in finding other support services. Medical costs of care of the children are likely to far exceed the financial resources of the family.

Classification of Intracranial Hemorrhage

Kosmetatos et al. (1980) found that prior to 1980, diagnosis of intracranial hemorrhage was generally made through postmortem examination or was inferred from physical signs, symptoms, and laboratory data. Direct diagnosis of the problem was not possible until later. Lazzara et al. (1984) reported on the usefulness of computerized tomography and real-time ultrasound in diagnosing intracranial hemorrhage. With more accurate methods of diagnosing hemorrhage came the possibility of more precise classification. Classification of intracranial hemorrhage today is generally by site of bleeding rather than by etiology. The classification of hemorrhage is arbitrary and subject to change as technology improves and the cause and nature of hemorrhage is better understood. Hemorrhage can occur in numerous different locations within the cranium, and the incidence varies according to the gestational age of the neonate.

The brain is surrounded by three layers of connective tissue called meninges. Between the layers are spaces. The meninges and spaces from outermost to innermost are:

- Dura mater
- Subdural space
- Arachnoid membrane
- Subarachnoid space
- Pia mater



Bleeding between the skull and dura mater is called an extradural hemorrhage, and bleeding below the dura is subdural hemorrhage. Both of these locations of bleeding are more common in term than preterm infants.

The largest part of the brain is the cerebrum. The outermost layer of the cerebrum is the gray matter of the cerebral cortex, which is made up of cell bodies and dendrites.

Cortical hemorrhages are more common in term neonates, but other intracerebral bleeds, including subependymal bleeds and bleeds into the white matter (cell axons), are more common in preterm neonates. Pape and Wigglesworth (1979) found that cerebellar and brainstem hemorrhages also occur more frequently in the preterm infant.

The most significant intracranial hemorrhages in VLBW neonates are intraventricular/periventricular hemorrhages in which blood fills the ventricles and extends into the adjacent brain tissue (parenchyma). Tarby and Volpe (1982) stated that it is possible that the bleeding in the infant's parenchyma may be a separate hemorrhage rather than an extension from the ventricular hemorrhage.

There is no nationally accepted standardized classification system of intracranial hemorrhage. See Table 1 for classifications of ventricular/periventricular hemorrhage cited in the literature. Today, radiologists tend to include abnormalities in addition to intracranial hemorrhage in their descriptions. Periventricular leukomalacia is one of the most significant abnormalities in VLBW neonates.

Ultrasound and CT Diagnosis of ICH

Ultrasound (US) is currently the most widely used method of diagnosing periventricular hemorrhage, but initially it had to be proven as an effective diagnostic tool in comparison to the CT scan. CT scan usually requires removing seriously ill neonates from their monitors and incubators and transporting them to the CT scanner in the Radiology Department. The infants are then exposed to X-rays during the CT scan. Ultrasound, on the other hand, is completed at bedside and does not require removal of monitors. The US scan is completed in a few minutes and does not require X-ray exposure.

In neonates, Ellington et al. (1982) reported that ultrasound imaging of the head is performed through the anterior fontanel or open sutures. The examination may be performed routinely in several planes to show different cross sections of the brain. A transducer is placed over the fontanel, and the image is visualized on a screen. Selected images are recorded on film for storage with patient records. Intracranial hemorrhage is strongly echogenic

Table I

Classification of Intracranial Hemorrhage

INVESTIGATOR	GRADE	CHARACTERISTICS
Papile, Burstein & Burstein (1978)	I	Bleeding restricted to the subependymal regions.
	II	Subependymal hemorrhage with extension into normal-sized ventricles.
	III	Subependymal hemorrhage extended into dilated ventricles.
	IV	Above, plus extension into adjacent brain parenchyma.
Kosmetatos, Dinter, Williams, Lourie, & Berne (1980)	4 groups in addition to a measure of ventricular dilation expressed as a ventricular/brain width ratio	Subarachnoid.
		Subependymal.
		Intraventricular.
		Parenchymal plus intraventricular.
Lazzara, Ahmann, Dykes, Brann & Schwartz (1984)	Mild	Subependymal only, or ventricular extension of blood fills 1/4 or less of anteroposterior diameter of the ventricular system.
	Moderate	Blood fills from 1/4 to less than 1/2 of the diameter.
	Marked	Blood fills 1/2 or more of the ventricular system.
Hutchson & Fleischer (1981)		<u>Hemorrhage</u>
	0	None.
	1	Subependymal layer only.
	2	Major site of hemorrhage in the subependymal layer, with a minor intraventricular hemorrhage.
	3	Major intraventricular hemorrhage.
	4	Intraparenchymal hemorrhage with or without subsequent leukomalacia or porencephaly.
		<u>Ventricular Dilation</u>
	0	Ventricular size 1-3 mm.
	1	Ventricular size less than or equal to 3 mm but present for less than 7 days.
	2	Mild (4-6 mm) ventricular dilation that does not progress.
	3	Progressive moderate (7-10 mm) dilation or severe (10 mm) dilation that is arrested or resolved spontaneously or through treatment.
	4	Progressive severe ventricular dilation requiring surgical treatment.
Levene, Fawer & Lamont (1982)	Mild	Originates in germinal matrix with no inferior or lateral extension beyond the most lateral border of the lateral ventricle.
	Moderate	Extends downward to basal ganglia on at least one side, or involves the caudate nucleus to the region of the genu of the lateral ventricle.
	Large	Any degree of extension laterally or superiorly into the cerebral parenchyma.

compared to brain tissues, and shows up on ultrasound as a dark area. A germinal matrix (subependymal) hemorrhage shows as an area of increased echogeneity (dark spot) in the area of the caudate nucleus and the telea choroidea. Intraventricular hemorrhage appears as strongly echogenic debris in the ventricle. Intraparenchymal hemorrhage presents as increased echogenicity extending from the subependymal region into the frontal or parietal cortex, sometimes into the occipital cortex, and rarely into the thalamus and midbrain structures.

Some researchers, including Mack et al. (1981), have assessed the merits of ultrasound versus CT scan diagnosis. In one study of 27 infants with intracranial hemorrhage, the CT scan was considerably better for detecting subarachnoid bleeding (sonography failed to detect all 13 cases identified by the CT scan) and for detecting small intraventricular hemorrhages.

Another study by Pape et al. (1983) compared the diagnostic accuracy of three neonatal brain-imaging techniques with cranial autopsy findings in 25 neonates born at less than 32 weeks gestation who died during the neonatal period. The researchers compared diagnostic accuracy for three sites of bleeding: germinal matrix, intraventricular, and intracerebral, which was defined as bleeding into brain parenchyma other than the germinal matrix. Brain imaging techniques included CT scan, linear-array real-time ultrasound through the skull bones, and compound B static-sector ultrasound performed through the anterior fontanel. The correlation of brain imaging with postmortem findings revealed that linear-array ultrasound was best at detecting germinal matrix bleeds, with agreement 76% of the time. The CT scan gave false-positive results 34% of the time because of difficulty in differentiating normal vascular tissue. Intracerebral hemorrhage was detected by all three methods at least 90% of the time. None of the methods effectively detected lesions less than or equal to 5 mm, and both ultrasound techniques missed lesions in the occipito-parietal area. The CT scan accurately diagnosed all intraventricular hemorrhages. Both ultrasound methods resulted in false positives in eight out of ten infants less than or equal to 26 weeks gestational age, because of the large choroid plexes. Sequential scanning improved the accuracy of diagnosis because of characteristic evolution of hemorrhagic lesions. The research suggested that for improved diagnoses, both the spatial resolution of the individual scanner and the maturity of the infant brain must be considered.

Using real-time ultrasound offers several advantages over CT scan in diagnosing neonatal periventricular/intraventricular hemorrhage: ultrasound is portable, it allows bedside scans, there is no need for sedation, and there is no exposure to ionizing radiation. Ultrasound equipment is less expensive than the CT scan, and the procedure does not require restraint of the infants nor their removal from incubators or respirators. No biological side effects have been noted in the studies of Allan et al. (1980) and Donn et al. (1981). Consequently serial evaluations are feasible.

Some problems may occur in using ultrasound for diagnosis of neonatal intracranial hemorrhage. It may be difficult to differentiate increased vascularity in the germinal matrix from small subependymal hemorrhage or extensions of the choroid plexes near the caudate nuclei, and to differentiate extensive subependymal hemorrhage from bleeding that partially fills the ventricles. Fleischer et al. (1981) reported that sonography may be difficult in a neonate with a small fontanel or overlapping sutures because of an inadequate portal for sonographic evaluation. The CT scan may be more appropriate in this case and for the assessment of the cerebellar region.

Clinical Patterns and Signs of ICH

Researchers have described three patterns of presentation of intraventricular hemorrhage in VLBW neonates.

- The first pattern is acute onset followed by coma and death. This is the *catastrophic* pattern. It may include abrupt deterioration of clinical status, seizures, bulging fontanel, hypotension, apnea, severe metabolic acidosis, and often rapid progression to death.
- The second, cited by Lazzara et al. (1980), is called a *stuttering* pattern. It consists of an acute episode with recovery, a quiet period, and repeated episodes, possibly due to a series of small bleeds. This pattern is a saltatory course with repeated improvement and deterioration, which eventually may result in death, although Volpe and Koenigsberber (1981) reported that most infants with saltatory deterioration survive the lesion.
- In the third pattern, the neonates show no overt deterioration; thus it is termed the *silent* pattern.

Pape et al. (1983) have divided the clinical signs of intraventricular hemorrhage into four categories, including neurological, cardiorespiratory, metabolic, and hematologic.

- Neurological signs include seizures, which are generally reported to be clonic seizures, extensor spasms, or decerebrate posturing. In preterm infants, severe hypotonia, apnea, abnormal eye movements, and rhythmic mouthing or grimacing movements may occur.
- Cardiorespiratory signs include pallor, cyanosis, hypertension, decreased urinary output, irregular respiration, increased apnea, bradycardia, and hyperthermia or hypothermia. These signs, however, do not always indicate intraventricular hemorrhage.
- Metabolic signs in the near-terminal stages may include severe metabolic acidosis and arterial hypoxemia, sudden glucose intolerance, and inappropriate antidiuretic hormone secretion.
- Hematological signs may show as a fall in hematocrit and a low platelet level or as extracranial bleeding.

Laboratory tests include examination of all of the following: the cerebral spinal fluid color, the cell glucose, and the protein content.

Some studies provide a correlation between clinical signs and CT scan or ultrasound documentation of hemorrhage.

Lazzara et al. (1980) assessed 98 infants of less than 35 weeks gestation for clinical signs of hemorrhage. Then CT scans were performed, which identified 37 (38%) of the infants who had hemorrhage. Of these 37, only 20 (54%) were predicted clinically. The clinical predictability was related to the severity of the hemorrhage in the infant.

Of three categories of hemorrhage severity in the study by Lazzara and associates, 81% of the marked category were clinically predicted, and 30% of the moderate and 36% of the mild hemorrhages were predicted. Four of the clinical signs were seen more frequently in infants with marked hemorrhage. These included fall in hematocrit, full fontanel, change in activity, and decreased tone.

Another study by Burstein et al. (1979) indicated that the frequency of silent intraventricular hemorrhage in a group of 100 infants with birth weights of under 1500 grams was as high as 68%.

The purpose of a study by Dubowitz et al. (1981) was to determine whether a detailed, frequent, sequential neurologic examination would reveal clinical signs that correlate with intraventricular hemorrhage as documented by real-time ultrasound.

The research by Dubowitz and associates correlated neurological signs with ultrasound abnormalities for three groups of neonates divided according to gestational age. For Group I (gestational age 31 weeks and below) and Group II (32 to 35 weeks gestational age), several neurological findings correlated strongly with the presence of intraventricular hemorrhage: impaired visual tracking, abnormally tight popliteal angle (decreased straightening of the knee), and development of roving eye movements. Decrease in tone and poor motility correlated in Group II. None of the signs correlated with ventricular dilation, but thumb adduction, mouthing movement, and abnormal Moro responses were frequently present.

A study by Partridge et al. (1983) also revealed that neither clinical deterioration, neurologic examination, nor hemorrhagic spinal fluid predicts the presence of intracranial hemorrhage.

Although clinical signs and symptoms appear to have little place in current diagnosis of intracranial hemorrhage, the symptomotology is important to treatment of LBW infants.

Intraventricular/Periventricular Hemorrhage (IVH)

INCIDENCE

Pape et al. (1983) reported that intraventricular hemorrhage occurs mainly in preterm infants of less than 32 weeks gestational age, especially before 30 weeks, and in neonates with birth weights less than 1500 grams. The lower the birth weight and the earlier the gestational age, the greater is the probability of IVH. Although incidence reports vary, nearly one-third to one-half of all infants admitted to neonatal intensive care units with birth weights below 1500 grams developed this hemorrhage to some degree. This is supported by the following studies: Tarby and Volpe (1982), Levene et al. (1982), Wigglesworth (1981), Garcia-Prats et al. (1982), Ment et al. (1982), Papile et al. (1978), and Ahmann et al. (1980).

Investigators have found the incidence of IVH to vary in the LBW neonates in accordance with other factors. In a prospective study of IVH by Clark et al. (1981), the only statistically significant difference found between the hemorrhaging and nonhemorrhaging groups was that more of the hemorrhaging group were born somewhere other than at their hospital (usually at another hospital). The only significance of this fact was that prenatal administration of glucocorticoids occurred in the infants born in their hospital, thus suggesting prenatal factors associated with IVH.

A retrospective study by Garcia-Prats et al. (1982) of 220 very low birth weight infants with gestational ages of less than 32 weeks was conducted in order to define the relationship between hyaline membrane disease and intraventricular hemorrhage. The researchers found that infants with hyaline membrane disease had a 56% incidence of intraventricular hemorrhage; those without the disease had an incidence of 31%. The infants with hyaline membrane disease also tended to have lower Apgar scores and were more likely to receive intermittent positive pressure ventilation. Garcia-Prats et al. noted that 58% of the ventilated babies developed IVH, while only 18% of the nonventilated group did. This suggests that therapeutic measures such as intermittent positive pressure ventilation could not be ruled out as contributors to intraventricular hemorrhages. Lee et al. (1979) reported the incidence of intracranial hemorrhage in infants requiring mechanical ventilation to be 70%.

A study by Levene et al. (1982) of 146 preterm infants to determine risk factors in the development of intraventricular hemorrhage revealed an IVH incidence of 36% in the study population. Respiratory complications in the infants were the best correlates of IVH, but respiratory distress syndrome, intermittent positive pressure ventilation, and continuous positive airway pressure were highly associated with IVH. They also noted that the more immature infants tended to have more severe hemorrhages. Just as Clark et al. (1981) had found in their study, Levene et al. also noted a greater incidence of IVH in neonates

born outside their hospital, but they found no other obstetric factors that seemed to increase the risk of neonatal IVH.

Greisen and Peterson (1983) studied the significance of vaginal versus cesarean delivery in association with intraventricular hemorrhage. The investigators compared methods of delivery for 152 low birth weight infants with the incidence of IVH. Vaginally delivered babies tended to have lower birth weights and gestational ages than cesarean deliveries. Therefore these data were corrected for gestational age. After this correction, there was a tendency for a higher incidence of IVH with the vaginally delivered babies, but this did not reach statistical significance.

ORIGIN

A study by Yakoviev and Rosales (1970) of 65 postmortem brains showed that 90% of the intraventricular/periventricular hemorrhages originated at the level of the foramen of Monro, with 20-40% of these lesions confined to the subependymal region without invasion of the ventricles.

An autopsy study by Leech and Kohnen (1974) of 184 infants with IVH showed that 90% of the hemorrhages were due to rupture of the periventricular hemorrhages into the lateral ventricles, with 4% originating in the choroid plexus, and the origin of the rest unidentified.

The injection of a stain into the vessels of children who died from hemorrhages indicated that the hemorrhages originated in the germinal matrix overlying the caudate nucleus. Pape and Wigglesworth (1979) and Hambleton and Wigglesworth (1976) reported that infants of 24-28 weeks gestational age showed hemorrhage over the body of the caudate, with hemorrhages occurring over the head of the caudate in older neonates.

A study by Pape et al. (1983) of 17 autopsies of neonates of 32 weeks gestational age or younger revealed bilateral intraventricular hemorrhage in 16 of them.

Tarby and Volpe (1982) reported that the primary lesion in intraventricular/periventricular hemorrhage is mainly bleeding from the small vessels and capillaries into the germinal matrix. The arterial supply to the area is derived mainly from the anterior cerebral artery via Heubner's artery, and the middle cerebral artery via the deep lateral striate arteries. On autopsy, severe bleeding generally spreads through the ependyma and throughout the ventricles and collects in the basilar cisterns of the posterior fossa, with clots in the occipital horns of the lateral ventricles, and in the subarachnoid space of the cisterna magna. Other studies by Pape et al. (1983) and Murton et al. (1985) support this. Hydrocephalus may develop secondary to the hemorrhage by blood clots and debris blocking the flow of the cerebral spinal fluid and by inflammation of the arachnoid, causing blockage.

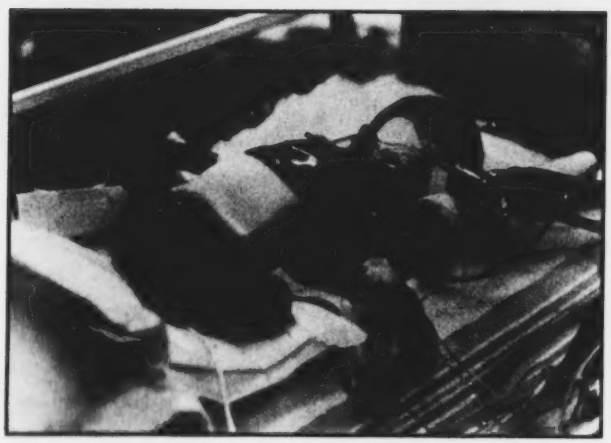
Autopsy study by Armstrong et al. (1987) of 24 brains of neonates who survived at least one week and were diagnosed as having IVH showed that 92% had additional cerebral abnormalities. These included periventricular leukomalacia, brainstem necrosis, hydrocephalus, or cerebellar necrosis.

TIMING

Intracranial hemorrhage in preterm infants appears to occur very early in postnatal life, and in some cases bleeding into the germinal matrix is believed to occur prior to birth. Milhorat (1981) reported that at his center, CT scans completed within the first 24 hours of life on infants weighing less than 1500 grams revealed intraventricular hemorrhages in approximately 65% of the neonates in that hospital.

Dolfin et al. (1985) also completed a study on the timing of hemorrhage diagnosis. They tested low birth weight neonates at 12, 24, 48, and 72 hours, and at 1 week and 1 month. They found that all hemorrhages occurred in the first 72 hours of life, with 25% detected within the first six hours of life. The total incidence of subependymal/intraventricular hemorrhage was 31% in their population; 56% of the neonates of less than 29 weeks gestational age were hemorrhaging.

In order to determine the optimal time for diagnostic cranial ultrasonography in neonates, Partridge et al. (1983) performed sequential evaluations on 64 preterm infants from birth to 1 year. All infants were less than 1500 grams at birth. Ultrasound was completed on days 1, 4, 7, 14, 21, and 28, and at months 3, 6, 9, and 12. The investigators detected hemorrhage in one or more sites at some time in 54.7% of the infants. All of the infants that hemorrhaged did so by day 14, with 90% hemorrhaging by day 4. Maximal diagnostic efficiency for ventricular dilation was on day 14 (80%), but all cases of ventricular dilation were detected by 3 months. The investigators reported that significant ventricular dilation is diagnosed later than intracranial hemorrhage.



The incidence of intracranial hemorrhage is especially high in babies requiring mechanical ventilation.

Murton et al. (1985) found that in a group of 225 VLBW infants, ultrasound diagnosis of periventricular hemorrhage revealed that all except one case of hemorrhage occurred within 72 hours after birth, and hemorrhage was detected by one hour after birth in 41% of the cases. In spite of frequent early onset of hemorrhage, this study found that it is not uncommon for later onset to occur. This happens particularly in infants who experience secondary hypoxic insult such as tension pneumothorax.

ETIOLOGY

Investigators do not know the cause of intracranial hemorrhage. Fluctuations in the cerebral vascular arterial and venous pressures have been implicated as contributing factors by Perlman et al. (1983), Wimberly et al. (1982), and Pasternak et al. (1980). Fluctuations may be caused by, or correlated with, a number of factors, including hypoxia, hypercapnia, nursing procedures, positioning, infusion of sodium bicarbonate and colloid solutions, tension pneumothorax, delivery method, and hypotension. The studies of Tarby and Volpe (1982), Kosmetatos et al. (1980), and Murton et al. (1985) support this.

Volpe and Koenigsberber (1981) have discussed the relation of IVH to prematurity. They found that the subependymal germinal matrix in humans does not dissipate until term. The matrix is weak support for the small vessels, and the vascular walls are relatively thin and fragile, thus making them vulnerable to insult.

Tarby and Volpe (1982) recognized mechanisms of brain injury associated with intraventricular/periventricular hemorrhage. Preceding hypoxic-ischemic insult, there is increased intracranial pressure and decreased cerebral perfusion, destruction of periventricular white matter, destruction of glial precursors in the germinal matrix, focal cerebral ischemia, and post-hemorrhagic hydrocephalus.

Outcome of Infants with Intracranial Hemorrhage

Until about 1980, because the diagnosis of intracranial hemorrhage was made by clinical or postmortem methods, Kosmetatos et al. (1980) found that an almost uniformly fatal outcome was assumed. With the advent of better diagnostic methods, Tarby and Volpe (1982) found that the majority of infants with intracranial hemorrhage live. Survival rates vary with the severity of hemorrhage. Almost all infants with mild hemorrhage survive and about 90% with moderate hemorrhages may survive. More than half of the infants with severe hemorrhages die, and the survivors often have significant morbidity.

Several studies published since 1980 have reported on the outcome of infants with intracranial hemorrhage. The findings of some of these follow.

Milhorat (1981) wrote that severe IVH-PVH is associated with a mortality rate of 90%, and that those who survive because of ventricular drainage and other medical management are often mentally retarded, or they have spastic diplegia or blindness.

Kosmetatos et al. (1980) reported that in a sample of 64 very low birth weight infants, 58% had hemorrhage, and 60% of these died. Hydrocephalus developed in two of the survivors.

Pasternak et al. (1985) noted that two-thirds of the premature infants of their study who survived large IVH-PVH developed porencephalic cysts at the site of the hemorrhage. Focal motor deficits contralateral to the porencephaly were frequently observed.

Babies with Grade IV intracranial hemorrhage may have to be shunted. They have a guarded prognosis.

Mack et al. (1981) indicated that follow-up of survivors of intracranial hemorrhage at 2 years of age suggested that 50% had significant neurological sequelae, and half of these were incapacitating.

Loewenich and Birkle (1981) reported on the morbidity of 43 term and preterm infants clinically diagnosed as having intracranial hemorrhage. Follow-up was at 1 year of age or more. The localization and size of bleeding was not defined. Six of the 43 showed severe neurological deficits including cerebral palsy, mental retardation, or microcephaly. Six had mild neurological deficits. There were transient neurologic deficits in 14, and 17 never showed any abnormality.

Ment et al. (1982) described the 1-year outcome of 61 neonates with birth weights less than or equal to 1250 grams. Of the 61 infants, CT scan or postmortem examination revealed that 52% had sustained either a germinal matrix or intraventricular hemorrhage. There were no survivors of Grade III or IV hemorrhages (using Papile et al. 1978 grading), but there were six survivors with Grade I, and 13 with Grade II intraventricular hemorrhages. At 1 year corrected age, there was no evidence of posthemorrhagic hydrocephalus in any of the infants. Six patients without hemorrhage and four patients with hemorrhage had either a mental or motor index of less than 80 on the Bayley Scales of Infant Development. Abnormal neurological examinations were found on one infant with hemorrhage and two infants without hemorrhage.

The results of this study suggested that there were no significant differences between the Grades I and II hemorrhage group and the non-hemorrhage group in development at 1 year corrected age.

Williamson (1982) compared severity of hemorrhage with neurodevelopmental outcome in 28 premature infants. The hemorrhages were graded using the Papile method. He classified the infants as abnormal, suspect, or normal at the time of follow-up at ages 13 to 34 months. Five infants were normal, eight were suspect, and 15 were abnormal. Of the 14 children with Grade I or II hemorrhage, five were normal, five were suspect, and four were abnormal. Of the 14 children with Grade III or IV hemorrhage, three were suspect and 11 were abnormal.

Naulty et al. (1983) reported on the outcome of 10 low birth weight infants who suffered Grade III intraventricular hemorrhages (as defined by Papile et al., 1978) compared to 10 control infants. The researchers evaluated all 20 of the infants every three months until 1 year of age. They completed hearing, speech, language, cognitive, motor, and neurological evaluations. The two groups did not differ significantly in growth; all the infants ranged between the 10th and 25th percentiles. One baby in each group showed respiratory problems related to bronchopulmonary dysplasia, and three IVH babies had retinopathy of prematurity. The neurological examination showed abnormalities on eight of the 10 IVH babies, including two with hemiplegia, one with double hemiplegia and one with suspected hemiplegia. Three of the 10 infants without IVH had abnormal assessments, including spastic diplegia, hemiparesis, and generalized hypertonia. Six of the IVH group showed cognitive and motor delays on the Bayley Scales of Infant Development; two of the non-IVH group were delayed. Seven of the 10 IVH infants and none of the infants without IVH had speech and language delay at 1 year, whereas three of the control infants showed suspected speech and language problems. The investigators noted that the three infants who had hydrocephalus had the poorest outcome and the most global damage.

Liechty et al. (1983) noted that ventriculomegaly follows a significant percentage of subependymal germinal matrix hemorrhages. Ventriculomegaly may develop into progressive hydrocephalus. A total of 89 infants who had CT scans as neonates received repeat scans and developmental evaluations at 1 year corrected age. The ventricle size was graded from 1 (smallest) to 5 (largest). No infant in category 1 was severely delayed (Bayley Scales of Infant Development Cognitive Index below 50) at 1 year. Most infants in categories 2 and 3 were normal or mildly delayed at 1 year. Of the 10 infants in categories 4 and 5, five were normal or borderline, and five were severely delayed. The researchers noted a statistically significant trend toward lower developmental scores with increased ventricular size.

Cooke (1983) discussed the outcome of 12 low birth weight infants treated for progressive post-hemorrhagic hydrocephalus by ventriculoperitoneal

diversion of cerebrospinal fluid. Nine infants had intraventricular hemorrhage with parenchymal extension, two had IVH only, and one had subependymal hemorrhage only. The shunts were placed from 32-154 days of age. Several follow-up medical and developmental assessments occurred, with a median length of follow-up of 20.5 months. In two infants, the lateral ventricles remained enlarged, probably because of cerebral atrophy. Porencephalic cysts remained at the site of extraventricular extension in eight of the infants. Four infants required shunt replacements because of shunt malfunction. The investigator noted that hydrocephalus may cause further impairment through ischemia of periventricular areas. Lowering intraventricular pressure through intermittent drainage may reduce ischemia. Cooke noted that the infants who received the most frequent shunt taps showed better developmental outcomes.

Scott et al. (1984) reported on the follow-up of a large percentage of VLBW infants from the Newborn Special Care Unit of the Yale-New Haven Hospital. All of these babies were routinely given CT scans and/or echoencephalography in order to detect the presence of germinal matrix or intraventricular hemorrhage. They were then divided into two groups, based on whether or not they had hemorrhaged, and were tested with the Bayley Scales of Infant Development on follow-up at 6 months, 12 months, and 18 months of age (corrected for prematurity).

The results showed that there was a significant decline over time in the Mental Development Index (MDI) of those babies with hemorrhage. Their mean MDI went from 94.4 at 6 months to 87.9 at 18 months, while the non-hemorrhage group's mean MDI went from 92.9 to 94.9 in that time. Infants with hemorrhage also had a significantly greater incidence of seizures (22% vs. 9%) than those babies without hemorrhage. These results are especially significant because the vast majority (91%) of the patients with hemorrhage had milder degrees of hemorrhage.

TeKolste et al. (1985) compared neurodevelopmental outcome of 81 preterm infants of less than 36 weeks gestational age, of which 38 had intracranial hemorrhages. Follow-up was at a mean age of 22.3 months, with a range of 8-38 months. As a group, the children with intracranial hemorrhage showed developmental indices in the normal range but about 10 points lower than the nonhemorrhaging group. The children with hemorrhages from mild to intraventricular with dilation performed similarly, but the two children with intraparenchymal hemorrhage showed a much poorer outcome. Both children with severe hemorrhage had cerebral palsy, retinopathy of prematurity with visual impairment, and below-normal development, although one showed cognitive development in the borderline range. Children with intracranial hemorrhage had more major abnormalities such as cerebral palsy, blindness, seizures, and retardation than the nonhemorrhage group. However, the incidence of minor problems in coordination, tone, and development was not significantly different between the hemorrhaging and nonhemorrhaing groups. Children in the hemorrhage group showed the following incidences of

Review of Literature

Summary

INVESTIGATORS	SUBJECTS/ METHOD OF DIAGNOSIS	AGE OF FOLLOW-UP	OUTCOME
Kosmetatos et al. (1980)	64 VLBW CT Scan	Less than 2 months	58% of the VLBW infants hemorrhaged. 60% with IVH died. Two survivors developed progressive hydrocephalus.
Pasternak et al. (1980)	Premature infants who survived large IVH-PVH hemorrhage CT Scan	5 months or less	66% of survivors developed porencephalic cysts at site of hemorrhage. Focal motor deficits contralateral to porencephaly were observed.
Mack et al. (1981)	Survivors of ICH US	2 years	50% had significant neurological sequelae, with half of these being incapacitating.
Loewenich and Birkle (1981)	43 term and preterm survivors of clinically diagnosed ICH	1 year or older	6 (14%) had severe neurological deficits. 6 (14%) had mild neurological deficits. 14 (33%) had transient neurological deficits. 17 (39%) showed no abnormality.
Ment et al. (1982)	61 neonates with birth weight less than 1250 grams. Papile et al. (1978) IVH grades. US	1 year	52% had germinal matrix or IVH hemorrhages. No survivors of Grades III and IV. No significant differences noted in development of hemorrhage vs. non-hemorrhage group.
Williamson (1982)	28 preterm. (14 Grade I, II) (14 Grade III, IV)	13-34 months	5 (35%) had normal neurological outcome. 15 (53%) had abnormal neurological outcome. Grades I, II: 4 (28%) Abnormal; 5 (36%) Suspect; 5 (36%) Normal Grades III, IV: 3 (21%) Suspect; 11 (79%) Abnormal
Naulty et al. (1983)	10 Grade III 10 Control Papile et al. (1978) IVH grades. US	3, 6, 9, 12 months	Growth 10th-25th percentile Control: 1 (10%) BPD; 3 (30%) Abnormal neurological; 2 (20%) Cognitive or motor delay; 0 Speech delay Grade III: 1 (10%) BPD; 8 (80%) Abnormal neurological; 6 (60%) Cognitive or motor delay; 7 (70%) Speech delay

INVESTIGATORS	SUBJECTS/ METHOD OF DIAGNOSIS	AGE OF FOLLOW-UP	OUTCOME	
Scott et al. (1984)	VLBW CT/echoencephalography	6, 12, 18 months adjusted age	No ICH Mean MDI from 92.9 to 94.9 by 18 mo. 9% seizures.	ICH Mean MDI declined from 94.4 to 87.9 by 18 mo. 22% seizures.
TeKolste et al. (1985)	81 less than 36 wk. G.A. (38 had ICH) US	8-38 months (mean = 22.3 mo.)	No ICH Normal developmental index	ICH Normal development; index 10 points lower 21% cerebral palsy 13% development ≤2 S.D. 5% hydrocephalus 5% seizures Two children with intraparynchymal ICH had CP, ROP, below normal development
Williams et al. (1987)	35 preterm VLBW grouped as hemorrhage (H) or without (WH) by CT scan	8-12 months and 5 years adjusted ages	At 5 years, 2 of the 4 children with Grade III or IV hemorrhages had spastic diplegia and mild mental retardation. Eight of 11 children in the H group were offered special education. The mean IQ of the H group was 85, and of the WH group, 96.	
Weisglas-Kuperus et al. (1987)	50 Preterm ≤35 wk EGA. 25 with normal US and 25 with abnormal. Six with Grade IV hemorrhages.	Neonatal US, 1 yr. US, 3-1/2 yr. developmental assessment.	At 1 year, 4 of 50 had developmental deficits, including 3 with CP. At 3½ years, 13 had developmental deficits, including 8 with CP. At 3½ years, none of the 4 children with Grade III hemorrhages had deficits. Five of 6 with grade IV hemorrhages had abnormal 1-year US scans. Incidence of CP was stated as high.	
Tamura and Hoyt (1987)	11 preterm with Grade III or IV by US or CT and who had abnormal ocular motility	When stablized in NICU and for follow-up at unspecified times	All had tonic downward deviation of the eyes, with 7 showing upward gaze recovery by 9-21 months. All had esotropia that remained. Three developed mild bilateral optic atrophy. None had visually significant retinopathy.	

US = Ultrasound
CT = Commuted Tomography

problems: cerebral palsy (21%), developmental retardation more than two standard deviations below the mean (13%), progressive hydrocephalus (5%), and seizures (5%). Only two-thirds of the nonhemorrhage group showed a completely normal outcome.

Although information on the group outcome of infants with intracranial hemorrhage is beginning to appear in the literature, it is not possible to predict which babies will do well and which will do poorly. This is illustrated in a report by Pasternak and Volpe (1979) on a preterm infant with IVH resulting in essentially total brainstem failure. This baby recovered spontaneously and made nearly normal developmental progress over the first year. After her hemorrhage she required 80% oxygen and was in a deep coma with no response to noxious stimuli. She remained in this condition for 120 hours before beginning recovery. The investigator emphasized that any prognosis formulated because of brainstem failure at that stage of nervous system development must be interpreted with caution.

As researchers conduct longer-term follow-up studies of children with neonatal hemorrhages, the inadequacy of predictability of early outcome measures is evident. A study by Weisglas-Kuperus et al. (1987) investigated the relationship between neonatal and 1-year brain ultrasound images and motor and mental development at 3½ years. The study indicated that the diagnosis of cerebral palsy increased with age. At 1 year, three of 50 children had cerebral palsy, but eight were diagnosed with CP by 3½ years. Two of the eight had normal neonatal and 1-year scans. All five children with grade IV hemorrhages had abnormal 1-year scans, but the two children with cystic periventricular leukomalacia (PVL) were the most severely mentally handicapped. None of the four children with Grade III hemorrhages showed developmental deficits. Because the incidence of developmental deficits tripled and cerebral palsy doubled from 1 to 3½ years, it is evident that longer-term follow-up is indicated to assess outcome.

Graziani et al. (1987) have classified ultrasound (US) abnormalities by hemorrhage grade, plus other abnormalities such as PVL, in order to analyze neonatal US correlates of cerebral palsy in 15 preterm infants. Of 139 children, all five who had Grade III or IV hemorrhages with periventricular cysts and progressive dilation of the ventricles had cerebral palsy; three of 10 with multiple large and persisting periventricular cysts following Grade III or less hemorrhage had CP; and none of 121 infants with scans of less abnormality had CP. They noted that the most common US abnormalities in the infants with cerebral palsy were large and bilateral periventricular cysts, which gradually resolved after nursery discharge consistent with PVL.

Papile et al. (1988) reported improvement over time for children with Grade III and IV hemorrhages. At under 2 years, 75% of 12 children were considered to have major handicaps. At 6-8 years, only 8% of these same children showed a major handicap.

Definition of Terms

Acidosis: A state characterized by the relative or actual decrease of alkali in body fluids in proportion to the acid content. Tissue function, most importantly the central nervous system, is often disturbed in this state. Inadequate ventilation causes respiratory acidosis by retaining carbon dioxide.

Anoxia: Absence of oxygen in inspired air, arterial blood, or tissues.

Apnea and Bradycardia (A's & B's): The cessation of breathing and slowing of the heartbeat.

Asphyxia: Extreme interference with respiration resulting in combining too little oxygen with too much carbon dioxide in the blood.

Caudate Nucleus: A portion of the basal ganglia gray matter lying adjacent to the lateral ventricles.

Choroid Plexus: A tuft of arteries in the ventricles believed responsible for the manufacture of cerebrospinal fluid.

Cisterna Magna: Fluid-filled cavity enlargement of the subarachnoid space under the cerebellum and behind the medulla.

Cranium: The skeleton of the head.

CT Scan: Computerized axial tomography—a radiologic technique that passes multiple X-ray beams through the body. A computer makes a composite image displaying numerous cross sections (slices) of the body part.

Ependyma: Cellular membrane lining of the ventricles and central canal of the spinal cord.

Germinal Matrix: Embryonic brain tissue overlying the caudate nucleus in preterm infants. The matrix has poor structural support and is highly vascularized. The germinal matrix is essentially gone by 40 weeks gestation, which is term.

Hypercapnia: Abnormally large amount of carbon dioxide in circulatory blood.

Hypoxia: Below-normal levels of oxygen in the air, blood, or tissue (but not low enough to be anoxia).

Intracranial Hemorrhage: Bleeding into the brain.

Intraventricular Hemorrhage: Bleeding into the ventricles of the brain.

Ischemia: Deficiency of blood to a body part.

Porencephaly (Porencephalic cysts): Abnormal condition of "holes" in the brain.

Real-Time Ultrasonography: The visualization of structures within the body or brain by recording the reflection of high-frequency sound waves directed at the tissues. The sound waves are beyond the range of human hearing. Real-time indicates the pictures are "live."

Subependymal: Beneath the lining of the ventricles.

Tentorium Cerebelli: A process of the dura mater that covers the cerebellum and supports the occipital lobes.

Ventricles: Spaces or canals in the middle portion of the brain that contain the watery cerebrospinal fluid that circulates around the brain and spinal cord. There are two lateral ventricles, one on each side, and a third and fourth ventricle.

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Positioning and Position-Induced Deformities

by Caryl J. Semmler, Ph.D., O.T.R.

Abstract

The position of neonates affects gastroesophageal reflux, aspiration, stomach-emptying, oxygenation, lung compliance, distribution of nasal airflow, intracranial pressure, behavior, sleep states, pooling of edema and blood, the development of soft tissue and cartilagenous and bony structures, and possibly the development of idiopathic scoliosis, handedness, and gait asymmetry. Prone positioning positively affects many of these functions, and supine affects others.

Many questions remain unanswered, including the following:

- What is the "normal" range of motion for VLBW infants?
- What is the characteristic orthopedic status of a VLBW infant?
- How much does positioning influence eventual orthopedic status?
- Does orthopedic development in VLBW infants parallel that of average-weight infants at the same adjusted age?
- How does the medical status of the neonate affect the later orthopedic outcome of that child?
- What is the optimal amount of time a VLBW infant should spend in each of the positions?
- Do VLBW infants need sitting-tolerance protocols before they can be discharged from the hospital?

More information is becoming available regarding positioning of neonates, but the questions still exceed the answers. The following recommendations and analysis of the literature will help in determining procedures applicable to low birth weight neonates.

Recommendations

Because little information is currently available on the usual orthopedic development of neonates, any recommendations must be considered tenuous and temporary until research and clinical management can clarify the most appropriate management methods. *The following recommendations are general; the needs of individual children must be considered.* Medical priorities may need to transcend developmental priorities, although both should be considered whenever possible.

The neonate positions are based upon the usual low muscle tone VLBW infant. Since hypertonia frequently becomes more of a problem as the child reaches an adjusted age of about 4-8 months, the positions may need to be drastically modified to accommodate problems secondary to hypertonia.

1. When possible, most of a neonate's time should be in prone position (rather than supine or sidelying). Keeping a neonate in prone position may decrease aspiration, gastroesophageal reflux, intracranial pressure, and idiopathic scoliosis and gait asymmetries. It facilitates stomach emptying and increases the stability of the chest wall with improved oxygenation and decreased energy expenditure.

   The head of the bed should be elevated 30 degrees. This may decrease intracranial pressure and gastroesophageal reflux.

   A hand should be placed close to the mouth, except if intubated. Doing this encourages oral facilitation, allows self-quieting, and improves shoulder adduction.

   The hips should be flexed and partially adducted (legs bent and fairly close together). Doing this discourages external rotation deformities of the legs. Do not overadduct the hips, because that could possibly encourage hip subluxation. Observe the effect on oxygenation as noted on oxygen monitors. If the baby is not on monitors, watch for free breathing without bluish color changes around the mouth or fingernails.

   Babies with dislocated hips *must* remain in the frog-legged position.

2. When you place the infant prone in a reflux harness, the hips should be partially adducted (thighs and knees fairly close together). Place the feet in neutral or turn them inward if the child's natural position is to turn out. Doing this discourages external rotation deformities of the legs, which are common in preterm babies.

3. When the neonate is on his back, the head should be in midline, if possible, with the hips partially flexed and adducted (legs bent and fairly close together) and the shoulders adducted (arms close to the body). This position

may decrease intracranial pressure and prevent skull flattening on the sides of the head, or scoliosis. It discourages external rotation deformity of the legs and horizontal abduction contractures of the shoulders.

4. When you place the neonate in a sidelying position, provide support under the head and place the arms close together and the legs close together. This position discourages hip abduction and shoulder horizontal abduction contractures. A soft or molded head support may prevent flattening of the sides of the skull, but the molding must not impede breathing.

5. Place the neonate at different times on both the right and left sides, although the left side is not recommended until the stomach has emptied after feeding (about 2 hours). Changing sides encourages symmetrical orthopedic development and may discourage asymmetrical rib flattening or scoliosis secondary to positioning. Stomach emptying is faster on the right than the left side.

6. Swaddle and hold the infant upright when you are trying to keep the baby alert. Swaddling decreases movement that may interfere with attending. Reflexive eye-opening may occur in the upright position. For babies that are rarely upright or have chronic lung disease, you may need to move them very gradually to upright to avoid rapid changes in heart rate and respiratory rate.

7. Physical and occupational therapists or nurses may manage minor neonatal or position-induced deformities by passive range-of-motion or passive stretch exercises or taping. Physician referral may be required, depending upon state licensure laws and hospital policy.

   Because spontaneous resolution of deformities cannot be guaranteed, the taping or exercising may facilitate resolution and help determine which deformities require medical or surgical intervention.

8. For neonates requiring orotracheal intubation, consider referral to a pedodontist for a palatal stabilizing device or for advice. The palatal device may prevent formation of a palatal groove or an acquired cleft palate.

9. Discourage infants and toddlers with specific deformities from sitting or sleeping in positions that encourage the deformity. Gently reposition them into an opposite movement. They should be encouraged to assume a variety of positions rather than overuse the same position.

   Infants whose legs turn out should be positioned so as to make the legs straighter by use of towels, by "tying" the legs together with a cloth diaper, or by tying the toes of a sleeper together. Check circulation. Doing this discourages external rotation deformity.

Discourage W-sitting and sitting on the feet. Habitual W-sitting may increase femoral torsion and decrease external rotation of the child's hips. Sitting on the feet may prevent spontaneous correction of internal tibial torsion and cause enlargement of the head of the talus (overgrowth of bone on the top of the foot), or tight heel cords.

Infants with flattened skulls should lie in a position that does not enhance the flattening. Monitor frontal-occipital head shape by placing a flexible French curve (available from drafting supply stores) to conform to the head, and then drawing the shape onto paper. Appropriate positioning discourages further development of abnormal head shape. Drawing the head shape allows documentation of change.

Encourage sidelying in babies under 1 year of age who have rib cage narrowing that appears to especially occur in babies with very low muscle tone or those with chronic lung disease. Ossification of the rib cage is not complete until about 1 year. Therefore sidelying may help encourage ossification in a wider position.

10. Infants and toddlers need only soft, flexible shoes, if they wear shoes. They do not require orthopedic shoes except if indicated for a specific condition as advised by the doctor or physical therapist. Soft shoes allow more flexibility for balance while still keeping the child's feet warm or protected. Orthopedic shoes may be unnecessarily restrictive and expensive and may interfere with stability in toddlers learning to walk.

11. Be aware of which preterm neonates have rickets, because they may be subject to fractures. Move these babies especially gently.

12. Learn the general referral criteria for local orthopedists in order to know when to involve them in orthopedic problems that are not currently being managed by a physician. Physicians vary in their referral criteria, but they may have general guidelines to assist with appropriate referral. Presumably, the major orthopedic anomalies will be identified while the infant is in the special care nursery, and position-induced deformities will be prevented through appropriate positioning.

13. In general, refer a baby for orthopedic assessment if the deformities are severe, asymmetrical, fixed, or painful. Children with congenital anomalies, hip dislocations, or central nervous system damage, such as cerebral palsy, should also be referred. Most mild intoeing or outtoeing resolves spontaneously by about 18 months.

14. Carefully assess breathing during feeding or breast feeding, and while using a car seat. The baby's head should not be too far forward or too far back. Extremely flexed or hyperextended head placement may result in upper airway obstruction, with apnea or bradycardia, or in aspiration.

Effects of Positioning

Brackbill et al. (1973) have studied some of the effects of positioning in term and preterm neonates as well as in infants with specific disorders. In newborn nurseries for term infants, the custom in the United States has been to place the infants primarily in the prone position. Neonates in the United Kingdom have been placed supine, although in recent years this has been changing. According to Konishi et al. (1987), neonates in Japan are also placed supine. Neonates in intensive care newborn nurseries may spend a considerable portion of their time supine, with the head turned to one side and the extremities in a frog-leg position. Even when placed prone, the infants will spontaneously assume the frog-leg position. Positioning can affect many body functions, so it is important to consider the effects of different positions.

INTRACRANIAL PRESSURE

Goldberg et al. (1983) found that head position has a significant effect on intracranial pressure in neonates weighing less than 2500 grams at birth. Placement of the head in midline appears to result in lower intracranial pressure than when the head is turned to the right. The higher pressure with the head turned may be due to mechanical compression of the neck veins. Elevation of the head of the bed 30 degrees for neonates with intracranial pressure 7 cm H_2O may also result in decreased intracranial pressure by promoting hydrostatic cerebral venous drainage.

Tarby and Volpe (1982) suggested that deformation of the compliant premature skull, which may happen during vaginal delivery, may contribute to increased venous pressure through obstruction of the venous sinuses.

Tarby and Volpe also implicated changes in intracranial pressure in contributing to intracranial hemorrhage. Seriously ill preterm infants with severe intracranial hemorrhage and marginal arterial blood pressure may have seriously impaired cerebral perfusion with a relatively small increase in intracranial pressure. These researchers suggested that the autopsy distribution of intracranial hemorrhage damage, with settling of blood in the occipital area during severe hemorrhage, is in part due to supine positioning of the infants.

GASTROESOPHAGEAL REFLUX

Meyers and Herbst (1982) reported on gastroesophageal (GE) reflux, a pediatric problem that may result in complications of failure to thrive, apnea, peptic esophagitis, recurrent pneumonia, and abnormal neurologic symptoms. The position of infants during and after feeding is one factor that may influence the occurrence of reflux. This study noted that reflux may be determined by a barium esophagram, a Tuttle test (lighted scope), an

esophagoscopy, an esophageal biopsy, and esophageal pH monitoring. Reflux can occur even without vomiting.

In a study comparing distal esophageal pH in nine infants under 5 months of age who had respiratory problems and repeatedly vomited, Orenstein et al. (1983) found that placing the babies in infant seats elevated 60 degrees increased the number and duration of reflux episodes to points greater than those that occurred by placing the infants prone horizontal.

Blumenthal and Lealman (1982) studied the effect of four positions on gastroesophageal (GE) reflux in 18 LBW babies from 2-31 days of age. They employed the prone, supine, right, and left-sided positions. Significantly less reflux occurred in prone than in supine position within one hour after feeding. The researchers noted no statistically significant differences between the lateral positions. They speculated that the reason for less reflux in prone was the relationship of air and fluid. In prone, the air rises to the fundus (upper, round portion of the stomach). The fundus forms a barrier between fluid in the pyloric antrum (lower bulge of the stomach) and the lower esophageal sphincter (the ring of muscles at the opening of the bottom of the esophagus).

A study by Meyers and Herbst (1982) of the effect of positioning upon GE reflux in 79 children with reflux and 49 without reflux showed that a prone position with the head elevated 30 degrees resulted in less reflux than the supine or upright positions in the group that showed reflux. This position was superior in preventing reflux both when the children (mean age 11.6 months) were awake or asleep. Position did not make a significant difference in the nonreflux group, which had a mean age of 28.8 months. In the patients with reflux, less occurred in upright than in supine when they were awake. More reflux occurred when these patients were awake than asleep in virtually every position studied.

ASPIRATION

To determine whether aspiration (inhalation of formula or secretions) in neonates is influenced by nursing posture, Hewitt (1976) studied 86 infants in a special care nursery. Milk aspiration was assessed by the presence of fat-filled macrophages in tracheal secretions. Macrophages are large cells that ingest foreign particles. The ingestion of fat by macrophages in the tracheal secretions indicates inhalation of the formula. Fat-filled macrophages were present in 32% of the infants nursed prone, in 77% of the infants nursed supine, and in 61% of the infants nursed in various positions.

STOMACH EMPTYING

Body position has been shown also to affect stomach emptying. Yu (1975) conducted a study of 48 neonates, including 12 each of term, healthy preterm, small-for-date babies, and infants with respiratory distress syndrome. Yu

noted the rate of gastric emptying to be the same for all except the respiratory distress group. These infants tended to show a high incidence of abdominal distension and pooling of feeds in the stomach in supine. Stomach emptying in the remaining three groups was more rapid in prone and the right lateral position than in supine and the left lateral position.

Researchers have also studied the pattern of stomach emptying in the same four postures by determining the percentage of residual stomach contents in neonates at 20-minute intervals for two hours. They examined 14 healthy infants under 28 days of age. Blumenthal et al. (1979) noted no significant differences in the pattern of stomach emptying as a result of posture, and infant patterns were found to be similar to adults. The combined mean rate for all four positions was to empty 2.3% of stomach contents per minute during the first 20 minutes and .2% to .6% per minute thereafter. The investigators suggested that their failure to confirm stomach emptying differences may be that the infants in the earlier study were less than 24 hours old, while true stomach peristalsis may not occur until two to four days after birth. Prior to that time, emptying may occur by muscle tone or elasticity of the digestive system, occasional final contracture, and hydrostatic pressure.

OXYGENATION AND LUNG COMPLIANCE

Position can affect oxygenation and lung compliance in preterm neonates. Alastair et al. (1979) conducted a study of 23 healthy newborn infants, 10 preterm (mean gestational age 34.5 weeks, S.D. ± 1.6), and 13 term small-for-gestational-age infants. Their purpose was to contrast the effect of posture on ventilation and lung mechanics in infants of similar birth weight but differing maturity. They studied the prone, the supine, and the right lateral positions.

Tidal volume (the amount of gas inspired and expired during one respiratory cycle), minute volume (ml of gas expelled from the lungs per minute), lung compliance (ml/cm H_2O), elastic work (gm/cm/min), inspiratory viscous work (gm/cm/min), total viscous work, and total work of breathing were significantly greater in prone than in supine for the preterm infants. Results in the lateral position were not significantly different from the prone or supine positions. Respiratory rate remained stable, with a mean of 43 breaths per minute (SD 11-12) in all positions.

The investigators noted that in prone, the diaphragm is raised and abdominal contents press against it, resulting in greater inspiratory viscous work. They noted that chest wall stability is important in preterm infants. The prone position may improve both the stability of the chest wall and the function of the diaphragm for improved ventilation. They recommended the prone position for preterm infants because of improved ventilation, in spite of increased work of breathing. Posture did not significantly affect tidal volume of lung mechanics in the term small-for-gestational-age infants.

Because most pulmonary diseases in neonates are associated with hypoxemia (decreased oxygenation of the blood), and lung instability, Wagaman et al. (1979) designed a study to evaluate the effect of four body positions upon arterial blood gases and lung mechanics. The study included 14 neonates recovering from lung disease who had a mean gestational age of 34.5 weeks (range 27-38). All these infants were studied by 2 weeks of age. The researchers evaluated the supine, prone with abdomen restricted, and prone with abdomen free positions. The head was in midline in all positions.

The investigators noted a significant increase in arterial oxygen tension, lung compliance, and tidal volume with prone positioning. No significant compliance change was noted in prone with the abdomen free instead of restricted. The investigators suggested that prone positioning allows greater excursion of the diaphragm unopposed by hydrostatic pressure. Newborn lungs are unstable and may tend toward more alveolar collapse in a dependent position, such as in supine, where the heart may press on more alveoli than in prone. Prone positioning might possibly be the most beneficial in patients with mild hypoxemia and infants with decreased lung compliance and a tendency to develop atelectasis (lung collapse).

In another study of 16 preterm infants with a mean gestational age of 32 weeks (range 27-34 weeks), Martin et al. (1979) also showed that infants demonstrated higher arterial oxygen tension when prone than when supine. Oxygen tension is a measurement of oxygen in the blood, which is generally between 50-80 mm Hg in preterm infants. The researchers noted a 15% increase in arterial oxygen tension in prone. There was a 25% increase for those infants with residual cardiopulmonary disease. As arterial oxygen tension increased, asynchronous chest wall movements decreased from 90% of the time in supine to 28% of the time in prone.

Abbasi et al. (1986) evaluated pulmonary functions in 10 healthy preterm infants at 39 to 41 weeks adjusted age. They evaluated nine pulmonary functions in supine, sitting, and semi-sitting positions. No differences in pulmonary parameters were found among the positions in these healthy preterm babies.

Martin et al. (1988) measured the distribution of nasal airflow in 12 healthy preterm neonates of adjusted ages 32 to 36 weeks. Airflow in each nasal passage was measured simultaneously in supine, with the infants' heads in midline and turned to the side. Turning the head resulted in an increase in tidal volume through the nares on the bottom side and a decrease on the upper nares, possibly because of partial obstruction of the oropharyngeal or nasopharyngeal airway on the upper side. Airflow imbalance was even greater when a nasogastric tube was in the upper nares. The asymmetry did not compromise overall minute volume in these healthy preterm babies, but it needs to be investigated whether a compromise would occur in younger, sicker neonates.

Bottos and Stefani (1982) confirmed the earlier findings that term infants spend more time sleeping when prone than when supine. The term infants slept 26% more time in prone than in supine and cried five times longer in supine than in prone. Investigators have also noted that the use of a hammock rather than a flat mattress in supine increases the length of time a preterm baby sleeps.

Bottos et al. (1985) conducted another study to evaluate the effects upon cutaneous oxygen levels of the flat supine position rather than the containing-supine position in a hammock. There were 40 preterm and 10 term newborns in this study. The investigators measured the transcutaneous oxygen level (measured through a device on the skin) for 23 minutes both in the hammock and in the flat supine positions. They noted no statistically significant differences in oxygenation between the two groups.

This study recommended the use of the hammock rather than supine positioning during the first weeks of life, when prone positioning is difficult. There were several advantages in using the hammock:

- It facilitates bringing the infant's hands to midline.
- It stimulates visual exploration by keeping the infant's head in midline.
- Multi-directional phototherapy can occur if the hammock is made of net.
- The staff can easily evaluate the status of the child because the face is showing.

They cautioned that in some infants with decreased compliance—for example, respiratory distress syndrome—the hammock position may decrease the baby's respiration.

Masterson et al. (1987) used 42 LBW infants as subjects in a prospective randomized study designed to evaluate the effect of supine and prone positioning on the energy expenditure and distribution of behavior states. Mean energy expenditure (calculated from measurement of oxygen consumption, carbon dioxide production, and urinary nitrogen excretion) was significantly greater in the supine position, 66.6 kcal/kg/d, compared to prone, 63.4 kcal/kg/d. Awake time in supine was 5.7% higher than in prone, which may have been related to energy expenditure.

Manara et al. (1987) demonstrated that prone positioning in adults with respiratory failure improves oxygenation. However, there were problems associated with prone positioning: development of edema around the eyes, difficulty with eye and face care, and increased tracheobronchial drainage.

ORTHOPEDIC DEFORMITIES

Clarren (1981) and Clarren and Smith (1977) found that constraints often cause deformations on otherwise normal tissue. Staheli (1977) confirmed that most deformities are structural, occurring at rest. Force exerted on the

musculoskeletal system due to positioning or ongoing pressure appears to have a significant impact on the orthopedic development of VLBW neonates.

OROFACIAL

Neonates treated in neonatal intensive care units are subjected to numerous procedures involving the oronasal pharynx, which may cause trauma to this area. Some of these procedures include endotracheal intubation either through the nose or oral cavity, use of nasal cannula or prongs for delivering supplemental oxygen, oral and nasal suctioning, oral or nasogastric tube feedings, and use of tape on the face to secure tubes. Complications such as local trauma to the mucosa, vagal stimulation with bradycardia (slowing of the heart caused by stimulation of the vagus nerve), subglottic stenosis (blocking of the airway that may be secondary to inflammation and scarring), lung collapse, tracheoesophageal fistula (hole connecting the esophagus and trachea), perforation of the esophagus or trachea, aspiration, and skin breakdown have been reported as a result of these procedures. Eye patches have caused facial distortion and eye problems. In addition, Nowak and Erenber noted deformities such as nasal cartilage erosion, palatal groove, cleft palate, and defective primary dentition from long-term intubaton or use of oral or nasal tubes.

A study by Nowak and Erenber to document the incidence of palatal groove formation in infants requiring use of orotracheal and orogastric tubes was completed by making impressions of the entire maxillary arch in 169 neonates. Of the 63 infants with orotracheal tubes, 42 were VLBW. Palatal groove formation was noted in 39.5% of the neonates who had orotracheal tubes for less than a week, and in 87.5% of those who had tubes over 14 days.

In 100 of 106 neonates with orogastric tubes in place from 1 to 50 days, Nowak and Erenber noted no palatal grooves. The remaining six with palatal grooves had previously been intubated. The investigators concluded that the incidence of palatal groove formation in orotracheal intubated infants is significant. Potential complications may include increased incidence of high, narrow palates and defective dentition. The reversibility of the groove is not known. The newborn palate is composed of immature, woven, fibrous, spongy bone with high osteogenic activity. The bone appears to be sensitive to continuous pressures, such as from orotracheal tubes, which may lead to development of grooves on the ridge and palate.

HEAD SHAPE

The elasticity of the skull to external pressure has long been evident. Sturtevant (1968) pointed out that early Northwest Indians intentionally flattened and elongated the skulls of their infants' heads by binding cedar bark strips to the calvarium. This treatment, which was discontinued at 6 to 8 months, ensured permanent deformity. Schendel et al. (1980) reported that in

the subjects of their study it took anywhere from several weeks to as much as three months to deform the infant's cranium permanently.

Coventry and Harris (1959) and Dunn (1974) noted that oblique constraint of the head may cause plagiocephaly during late uterine life. The constraint may also cause congenital muscular torticollis. Deformational plagiocephaly and muscular torticollis occur in approximately 1 in 300 live births. The plagiocephaly may become more pronounced in the supine position. Plagiocephaly may occur in preterm or other infants who lie in a limited range of positions. Deformational plagiocephaly should spontaneously resolve in most infants, but Clarren et al. (1979) have noted that removal of deforming forces does not always ensure resolution. About 10% of infants with plagiocephaly may have persistence of mild to severe cosmetic deformity (although VLBW infants are not included in this data.)

Using a specially made helmet similar to a football helmet is one method of treating plagiocephaly. Wearing the helmet provides mechanical forces to reshape the baby's head to fit the helmet. In a study of helmet treatment implemented at 4 to 10 months in 28 infants with severe plagiocephaly, 19 secured normal head shape, and the remaining infants showed improvement. The average treatment lasted 5.3 months. None of 10 untreated infants obtained normal head shape. Every child with a helmet showed mild scalp odor, one developed dermatitis, and two showed superficial pressure ulcers.

Clarren's study recommended that helmet treatment not be implemented before 6 months of age (adjusted for preterm infants), because rapid brain growth during the first few months of life can result in spontaneous improvement. They also recommended no treatment after 18 months since there is no significant remaining brain growth to redirect the head. Head circumference growth of approximately .6 cm per month between 6 and 18 months is not sufficient to reform skull deformities spontaneously. Thus helmet treatment is indicated during that period.

Wynne-Davies (1975) found an association between plagiocephaly, some infantile idiopathic scoliosis, and positioning. (Idiopathic means the cause of the condition is not known.) A genetic, clinical, and epidemidological survey was conducted in Edinburgh, Scotland, in order to determine etiological factors in infantile idiopathic scoliosis, which occurs under 4 years of age. Earlier information indicated that infantile scoliosis was seldom present at birth but occurred during the first few months of life. The data noted that most curves were convex to the left, and the gender ratio was about three males to two females. The study revealed that of 97 infants developing scoliosis by 6 months of age, 64% resolved spontaneously. Thoracic curves were noted in 98% of the infants, and plagiocephaly was present in all of the infants. The recessed side of the head was always on the same side as the convexity of the curve, which was the left side in 76% of the infants.

After examining numerous factors, Wynne-Davies suggested that idiopathic infantile scoliosis has a multifactorial etiology. A genetic tendency may be present that can be triggered by environmental factors. Wynne-Davies speculated that static positioning may be an important factor. He noted that the incidence of scoliosis in a similar genetic pool in Boston where infants are placed prone was much lower. Only three of the study infants were routinely placed in prone.

A more recent retrospective study by McMaster (1983) helps explain the differences between the Boston and Edinburgh incidence of infantile scoliosis. Previous information indicated that of all patients with idiopathic scoliosis in the Edinburgh survey, 50% were infantile. Only .5% of the Boston survey were infantile. McMaster's subsequent retrospective study of all new scoliosis patients under 18 years of age who presented at the Edinburgh Scoliosis Clinic from 1968 to 1982 indicated that infantile idiopathic scoliosis may be a preventable deformity. The infant's resting position may be a causative factor. This inference was drawn from the fact that the relative frequency of infantile curves decreased from 41% before 1980 to 4% after 1980, which appeared to coincide with caregivers using more prone placement of infants and less restrictive wrapping. The research indicated that the reason for greater left-sided curves was the tendency for supine infants to roll partially to the right, resulting in uneven mechanically deforming pressure on the rib cage and skull. The plagiocephaly was sometimes accompanied by a forward-protruding "bat ear" caused by the resting position on the mattress. Previous statistics of the incidence of plagiocephaly in normal term Edinburgh infants was cited as 20%, and 63% in preterm babies.

Baum and Searls (1971) reported on head shape and size of preterm LBW infants with a mean weight of 1590 grams. They obtained weekly head shape recordings, including anteroposterior (AP) and biparietal (BP) diameters, for a mean of 31 days with 14 babies. All showed progressive head flattening. No serial head shape circumferences were obtained beyond about 3 months of age. Based upon the mean birth weight, it was decided that many of the babies were not VLBW. The study also revealed that 45 ex-preterm adults showed a persistence of the skull deformation acquired neonatally.

Position-induced dolichocephaly.

Largo and Duc (1977) described AP/BP indices of 40 healthy preterm babies born at 32 and 36 weeks gestation. They followed these infants for six months; the largest AP/BP ratios appeared four weeks after term gestation, with the earlier babies showing more head flattening.

Coffin (1986) reported on head shape from medical records of 1,064 pediatric patients. He noted that 90% of the infants showed head and corresponding brain asymmetry that begins in utero, with a left occipital and right frontal prominence that he termed "left-headedness." Measurements by palpation of the head appeared crude, with no report of reliability of measurement. He attempted to determine when the asymmetry was established by ultrasound study of 100 fetal heads. He noted left-headedness in 92% of them. Assessment of 200 CT scans of patients demonstrated that the brain showed the same asymmetry as the skull.

Little information has been found regarding prevention of head flattening in preterm infants. Kramer and Pierpont (1976) and Marsden (1980) noted that the use of waterbeds instead of mattresses decreased the amount of skull flattening. Konishi et al. (1987) found that their experimental group of preterm neonates placed in prone position in the nursery did not show the persistent right head turning and skull asymmetry that the supine control group showed. Their supine control group tended to get occipital flattening.

In a two-subject research study, Semmler et al. (1987) attempted to prevent position-induced dolichocephaly in these VLBW neonates by using specially designed supine and prone positioners. Anteroposterior/bitemporal (AP/BT) ratios showed statistically significant and clinically obvious maintenance of head roundness for a baby on the positioners compared to a baby on the mattress. They suggested that head shape may be easier to maintain in supine with molded positioners than it is in prone. Contouring the mattress surface with the baby placed prone raised concerns about upper airway obstruction.

Detlefsen's 1987 survey of upper-midwest neonatal nurses indicated that 85% of the 33 respondents' nurseries provided intervention to affect head shape. These interventions included sandbags, waterbeds, waterbed pillows,

Skull flattening affects the perception of "cuteness."

"doughnuts," sheepskin, egg crate mattresses, and repositioning. Intervention frequency was often every two to four hours. The most common intervention side effect mentioned was agitation, but they also noted airway obstruction, apnea, bradycardia, emesis, tachycardia, and decreased oxygenation.

Although literature is available on the deforming effects of pressure on the facial and skull structures of VLBW neonates, little research information has been located on the effects upon the extremities.

Normal Orthopedic Development

According to La Rocca (1978), development of the skeletal system follows an orderly sequence. Growth involves changes in shape as well as in length of bones. Bones enlarge by adding to the surface of the bone rather than to the area within the bone. Chabner (1976) noted that the embryo begins with cartilage rather than bone. Embryonic bone forms either through intramembranous ossification or cartilaginous ossification. Growth at the ends of the bones occurs by laying down bone on a cartilaginous structure, noted Mosley (1978), and growth on the outer bone surface is membranous ossification, or laying bone directly on the surface. The process begins in standard primary ossification centers of some bones by the eighth week post-conception. Before birth, there are primary ossification centers in all bones of the arms and legs (except for some small bones) and the kneecap. Usually only one secondary ossification center is present before birth, and this is located in the lower portion of the femur. After birth, other secondary ossification centers develop, and ossification can occur into adulthood.

Bone is a living and dynamic tissue that is subject to remodeling based upon mechanical or other demands. Mosley observed that external stresses can cause deformation of the bone. Some portions of the bone can resorb and others can build up. The effect of mechanical force on the growth plate is not totally understood, but extrinsic forces can have an effect. Note the uneven growth sometimes caused by casting.

Residual nasal distortion and dolichocephaly in a 20-month-old baby.

Cartilage is much less stiff and more viscous than bone. Therefore its shape can be more easily changed by pressure. Soft tissues, including muscles, tendons, and ligaments, also respond to mechanical forces exerted upon them. Muscle fibers may shorten, lengthen, or increase or decrease diameter based upon range of movement, amount of resistance, or degree of immobilization. Tendons may hypertrophy, depending on the workload placed upon them.

Generally, LaRocca explained, the more rapid the orthopedic development or the earlier an insult to that development occurs (as in utero), the more profound will be the resulting derangement.

Distinctions need to be made between pathological changes and normal, predictable changes in bone growth patterns, as well as between cosmetic and functional deformities. Angular and rotational malalignments are common in children, and many of these problems spontaneously resolve. Kling and Hensinger (1983) noted that common angular malalignments include bowlegs and knock-knees. From birth to 7 years, LaRocca maintains, children normally progress from bowlegs to knock-knees to straight legs.

Inward rotational malalignments include metatarsus adductus, internal tibial torsion, and femoral anteversion. Metatarsus adductus is frequent in normal newborns and is probably related to intrauterine positioning. According to Hensinger (1981), up to 90% of children will show spontaneous resolution by 3 years of age, but guidelines for predicting which will not resolve are not available. Metatarsus adductus may be abnormally fixed, in which case the feet cannot be forced into normal alignment by applying pressure, or it may be dynamic, thus allowing normal alignment. With a dynamic deformity, the lateral border of the foot can be moved from a convex shape to a straight side without changing the position of the heel.

A large portion of normal neonates *may* have internal tibial torsion, although there is no completely accurate way of measuring tibial torsion. The axis between the lateral and medial malleoli is frequently used to consider the degree of torsion. In children, noted Hensinger, this is tested in a seated position. In the normal fetus, the medial malleolus is posterior to the lateral malleolus. The malleoli should be level at birth, and by walking age the medial malleolus should be anterior, with about 20 degrees external tibial torsion. Kumar and MacEwen (1982) observed that spontaneous resolution occurs in most children by 18 months of age.

Femoral anteversion (internal femoral torsion) is anterior rotation of the femoral neck axis in relation to the frontal plane of the femoral condyles. This can be measured by X-ray but is noted clinically by increased internal rotation of the hip, with little external rotation. An assessment can be made with the child lying supine with the legs straight, or on the stomach with the knees flexed. It is difficult to draw any firm conclusions from the data, however, because the normal hip range noted in neonates has varied from one

investigator to another. Hensinger stated that internal and external rotation should be equal at about 45 to 50 degrees. Haas et al. (1973) noted that newborns have a mean of 62 degrees (SD 12.9 degrees) internal rotation and 89.1 degrees (SD 14.3 degrees) external rotation. A more recent study by Drews et al. (1984) suggests that normal newborn hip internal rotation is 79.8 degrees (SD 9.3 degrees), and external rotation is 113.7 degrees (SD 10.4 degrees). Internal femoral torsion spontaneously decreases with age. The average angle of torsion is 40 degrees at 3 months, and there is a decrease of about 2 degrees per year from 2 to 10 years. Hensinger noted that children with increased femoral torsion may characteristically W-sit. More than half of the children with increased femoral torsion may normalize their gait through compensatory external tibial torsion.

External rotation deformities with external rotation gait is less common than internal rotation deformities. Investigators noted that external rotation of the hip is common in neonates, but that may be due to soft tissues rather than true femoral retroversion. External rotation may persist due to sleeping position, but Hensinger noted that this problem usually resolves spontaneously at the time of walking.

An orthopedist or other physician should monitor orthopedic development outside the expected normal parameters, although this judgment may be difficult since orthopedic development of VLBW infants is not well-documented. Minor deformities may be modified through positioning or exercise, but deformities that do not spontaneously resolve may require casting, splinting, or surgical intervention. Very low birth weight infants may have their orthopedic development complicated by cerebral palsy, inadequate nutrition, infections, rickets, congenital malformation, or a host of other medical problems.

Orthopedic Status

Normal Foot

Metatarsus Adductus

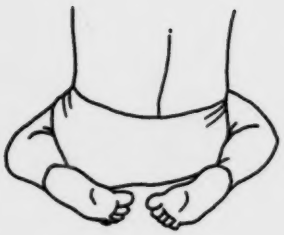
Toeing Out

Contractures of Soft Tissues in External Rotation

Femoral Retroversion

External Tibial Torsion or Rotation

Valgus Foot



Sitting on Feet

W-Sitting

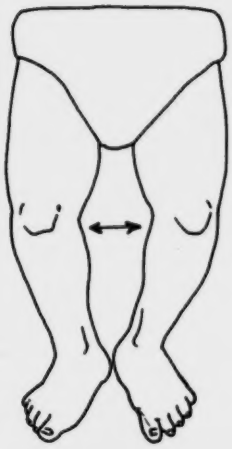
Toeing In

Femoral Anteversion

Internal Tibial Torsion or Rotation

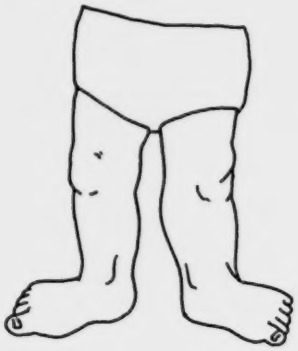
Metatarsus Adductus

Adductor Spasticity



Bowlegs

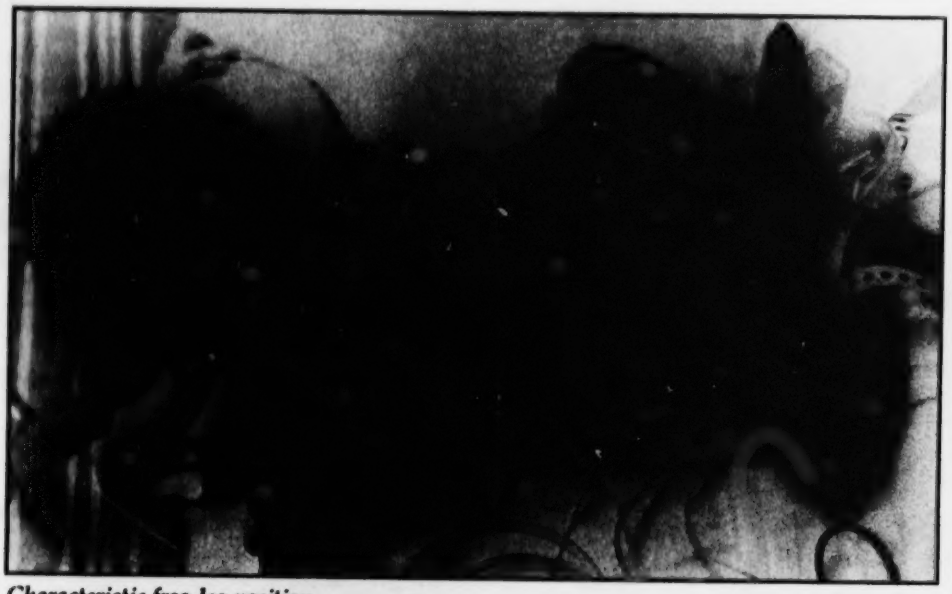
Knock-Knees



External Rotation Gait

Susceptibility to Deformity

It is difficult to locate any representative orthopedic and range-of-motion data on VLBW infants. Clinical experience suggests that VLBW infants may have characteristic position-induced deformities, although the incidence and spontaneous resolution of these probable deformities have not been documented. VLBW infants are likely to be more susceptible to position-induced deformities for any of the following reasons: more cartilagenous structures, low muscle tone with apparent increased range of motion of the large joints, prolonged supine and prone positioning in a frog-leg position, and medical complications necessitating invasive equipment.



Characteristic frog-leg position.

As noted in the illustrations of the resting postures of term and preterm neonates, the positions are very different. The sleep state of the infant influences its posture. Casaer (1979) observed that in term neonates, antigravity muscle tone decreases during light sleep. Preterm neonates spend a large portion of time in light sleep.

The literature suggests that deformities of turning inward (internal tibial torsion, internal femoral torsion, and metatarsus adductus) are more common than outward rotations in normal development, but this may not be true in VLBW infants.

In a clinical setting, the following deformities in VLBW infants appear when they are placed on flat mattresses. These deformities rarely occur in average-weight neonates.

- Skull flattening on the sides of the head, with subsequent narrowing and lengthening of the skull (dolichocephaly). This has been clearly documented by observation in the NICU.
- Decreased depth of the rib cage.
- Hip external rotation deformities with hip abduction contractures.
- External tibial torsion or rotation of the tibia.
- Shoulder horizontal abduction contractures characterized by "W" arms.

Although occupational and physical therapists have noted problems clinically, measurement of these deformities is extremely difficult and unreliable. This makes objective, measurable documentation necessary.

Some Typical Resting Postures

(Positions vary considerably and change often.)

TERM PRONE

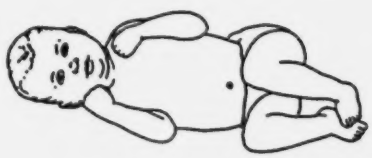
Hand to mouth
Pelvis high
Legs close together
Weight distributed primarily on forearms and knees
Hands fisted

PRETERM PRONE

Hand away from mouth with shoulders abducted ("W" arms)
Pelvis low
Legs spread apart with feet turned outward
Entire bottom side of body appears to touch bed
Hands open

TERM SUPINE

Arms and legs close to the body with little limb surface touching the bed
Head stays in midline or slightly to side
Hands fisted



PRETERM SUPINE

Arms and legs away from the body and externally rotated (frog-legs)
Head turned flat against the bed
Hands partially open

Implications of Position-Induced Deformities

The literature contains little documentation about the consequences of allowing VLBW neonates to develop the deformities described previously. Some of the questions that remain include the following:

- Do the deformities significantly affect the achievement of developmental milestones such as reaching, crawling, and walking?
- Can rib-cage narrowing affect the respiratory system of VLBW infants, particularly those who already have compromised respiratory function (such as bronchopulmonary dysplasia)?
- How do the cosmetic problems of these deformities affect the amount of attention parents and professionals give these babies?
- Can the deformities have lasting effects on the self-concepts of these children as they grow older?

One study by Elliman et al. (1986) suggested that narrow heads of preterm babies are not correlated to developmental delay in children up to 3 years of age. Some evidence suggests that the cosmetic effects alone may be significant. Berscheid and Gangestad (1982) stated that ". . . a person's physical attractiveness is anything but a 'superficial' characteristic that plays only a minor role in a person's life." Physical attractiveness has important implications for development, beginning as soon as a baby is born. A study by Carter et al. (1978) showed that nurses caring for preterm infants predict higher intellectual abilities for the babies they perceive as physically attractive. Langlois (1981) found that unattractive babies receive different treatment from their mothers. Hildebrandt and Fitzgerald (1976) observed that teachers and college students who took part in the study provided less visual attention to unattractive infants. Physical attractiveness is important to popularity with preschool peers, as well as to teacher attention and evaluation of the child. These observations were confirmed by Kleck at al. (1974) and Clifford and Walster (1973).

Budreau (1987) summarized studies suggesting that the "babyness" of an infant may serve to elicit caregiving and affective responses. Round head shape, short and narrow features, large eyes, and large forehead determine the perception of infant cuteness. College students in the study judged craniofacial features of preterm babies who did not yet have position-induced dolichocephaly to be less cute, less likeable, and less desirable for interaction.

Positioners

One way to prevent position-induced deformities in VLBW neonates is currently under investigation by occupational therapists at the University Affiliated Center in Dallas. That is the use of positioners. A United States patent search revealed several patents on positioners and seating systems. The relevant patents were on an orthodontic cradleboard, an orthopedic support for infants, a mattress of novel shape, a surgical table for small infants, and a survival couch for the Gemini space missions. (See the list of patent holders at the end of this article.) None of these patents met a significant number of the positioning "ideals" listed by the investigators. (See the checklist following.)

These ideals have been compiled by comparing results in the literature with single-subject research studies on positioners. This list evaluates neonatal position in general. Obviously, no positioner can meet all of the criteria fully. Further, the criteria may change as more research studies are conducted upon the immediate and long-term effects of position upon VLBW neonates.

Commercially available positioners may prove to be a cost-effective method of preventing position-induced deformities in the future, as well as enhancing other body functions, but more research must be conducted to evaluate efficacy, safety, and utility. If the use of positioners could decrease the amount of therapy time to prevent deformities and also decrease the amount of overstimulation and handling received by the very ill babies (such as those with chronic lung disease), they may save money. Costs could be reduced by decreasing therapy time to stretch out acquired contractures and lessening the need for orthopedic consultation on position-induced problems. If decreased handling helps conserve an infant's energy and increase weight, shortening hospitalization by even one day would save over $1000 in hospital costs.

A supine positioner by Semmler, Cook, and Smith is scheduled for commercial distribution by Alimed Inc. A prone positioner has not yet been submitted for commercial consideration pending further research. Supine support pillows are available from Ohio Medical Instruments Co. Beanbag Premie Comfort Pads without a preset form can be purchased from Patient Comfort Products, 3745 Purdue St., Dallas, Texas 75225. Little, if any, research has been completed on the efficacy of any of these products.

Neonatal Prone Positioner Ideals Checklist

___ Supports ribs.
___ Leaves abdomen free.
___ Leaves hips partially flexed and adducted.
___ Leaves knees partially flexed.
___ Prevents hip external rotation but does not overcorrect.
___ Keeps head midline or not totally flat to the side.
___ Prevents oral-facial malocclusion.
___ Will not let baby slide off or wiggle out.
___ Keeps baby accessible for nurse observation.
___ Allows for diaper changes.
___ Allows for gavage feeding.
___ Allows for starting IVs.
___ Can be used with X-ray.
___ Allows for sheet changes.
___ Allows for or encourages hand to mouth.
___ Accommodates wires, electrodes, and tracheostomies.
___ Is cleanable or disposable for infection control.
___ Allows for some growth.
___ Keeps neck extended enough to prevent obstructive apnea and bradycardia, but not so hyperextended that it results in aspiration of secretions.
___ Will not cause decubiti.
___ Requires little storage space.
___ Is easy to use with minimal instruction required.
___ Is easily inserted and removed.
___ Will not interfere with resuscitation procedures.
___ Restrains without immobilizing.
___ Is cosmetically appealing.
___ Allows for sidelying and supine position as well as prone.
___ Has minimal parts or fasteners.
___ Does not interfere with nursing care.
___ Is comforting to the baby.
___ Is inexpensive or cost-effective.
___ Is similar to current practice.
___ Is applicable or easily adaptable to suit a large number of babies.
___ Maintains or increases oxygen saturation.
___ Allows respiratory therapy procedures.
___ Accommodates an oxygen halo.
___ Fits in an open bed.
___ Does not increase intracranial pressure.

Checklist developed by
Carol Cook, M.O.T., O.T.R.
Caryl Semmler, Ph.D., O.T.R.

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Definition of Terms

Cartilage: Flexible, rubbery connective tissue found at the end of bones, in the embryonic skeleton, and in the ribs, nasal septum, respiratory tubes, and external ear of the adult.

Condyle: Knuckle-like prominence at the end of a bone near the joint.

Dolichocephaly: Narrow head width with elongation front to back.

Femoral Anteversion or Internal Femoral Torsion: Inward twisting of the femur (thigh bone). This is a common cause of in-toeing gait in children.

Femoral Torsion: Twisting of the femur on its longitudinal axis.

Genu Valgum: Knock-kneed.

Genu Varum: Bowlegged.

Ligament: Connective tissue adhering bones to bones.

Malleolus: Medial—Ankle bone on the inside of the leg. Lateral—Ankle bone on the outside of the leg.

Metatarsus Adductus: Inward turning of the forefoot.

Ossification: Process of forming bone.

Palatal Groove: A narrow groove of variable depth located near the midline of the palate.

Plagiocephaly: Rhomboid-shaped flattening of the head that may be due to pressure on the head such as from lying on a flat mattress or, rarely, from a malformation of the brain or asymmetrical closure of the skull sutures.

Prone: Lying on the stomach.

Scoliosis: Lateral curvature of the spine with associated rotation of the vertebrae.

Soft-Tissue Deformities: Deformities, such as turning out of the legs, that are caused by the stretching or shortening of ligaments, tendons, muscles, or other non-bony structures.

Supine: Lying on the back.

Tendon: Connective tissue connecting muscles to bones.

Tibial Torsion: Twisting of the tibia (shinbone) on its longitudinal axis. The twisting may result in *Internal Tibial Torsion (ITT):* Inward twisting of the tibia that results in an in-toeing or "pigeon toed" appearance. *External Tibial Torsion:* Outward twisting of the tibia that results in toeing-out.

Torticollis: Shortening of neck muscles on one side, with the head turning to that side.

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Low Birth Weight Infant Follow-Up at Children's Medical Center, Dallas

by Elizabeth Heyne, M.S., Child Health Associate, PA-C

Abstract

The increased incidence of LBW infants in the United States has made the need for follow-up of these high-risk infants imperative. Children's Medical Center of Dallas Low Birth Weight Clinic provides comprehensive follow-up care for Parkland Memorial Hospital infants weighing less than 1000 grams and for ventilated babies until age 18 months. The LBW Clinic follow-up program has its limitations, but it strives to provide a comprehensive approach to the high-risk patients it does serve.

The LBW Problem

With the increased sophistication of both personnel and equipment available in the Level III nursery, the modern NICU allows many more preterm infants to survive than was possible a few decades ago. However, this success has brought a major new public health problem to national attention.

The problem is at least four-fold:

1. The incidence of LBW births
2. The demographics related to these infants
3. The cost of the NICU
4. The eventual outcome of this high-risk population of infants

DEMOGRAPHICS

The Committee to Study the Prevention of Low Birth Weight has concluded that a variety of factors is clearly associated with LBW. Demographically, the principal risk factors include maternal age under 17, single marital status, low socioeconomic status, less than 12 years of education, and being black.

INCIDENCE

The incidence of LBW births (less than 2500 grams) nationally in 1981 was 6.8%. Of those births, 1.2% were VLBW (less than 1500 grams). The Surgeon General specified a need to reduce this high rate so that "by 1990, LBW babies . . . should constitute no more than 5% of all live births." The Institute of Medicine is undertaking a major thrust to prevent LBW births and to comply with the 1990 goal. One important step is to ensure the availability of prenatal care for all at-risk mothers. It is hoped that more widespread education of the women of child-bearing age regarding the ill effects of smoking, alcohol consumption, use of recreational drugs, poor diet, stress, and venereal diseases on their fetuses will alter the lifestyle of at-risk women, and thereby decrease their chances of premature delivery.

COST

Much effort and money is invested in VLBW infants. The average cost of a typical three-month stay in a Level III NICU is between $30,000 and $90,000. On a yearly basis, the nation's NICUs spend $2.5 billion. Medicine has never put a price tag on human life, but the taxpayers of the United States must wonder when and how this public health issue will be alleviated.

OUTCOME

Unfortunately, the generally favorable outcome of VLBW infants born to middle-class mothers is not duplicated in lower socioeconomic classes. Recovery from problems during birth and in the NICU is a prolonged process that is greatly influenced by an infant's home environment. Socioeconomic factors including maternal education, marital status, and social class are better predictors of developmental outcome of the VLBW infants after discharge from the NICU than are factors such as birth weight or Apgar scores. The rate of developmental delay and neurologic problems among infants born at Parkland Memorial Hospital, which is a county hospital, is two to three times that reported for middle-class families.

Having defined the problem in general, this article will now focus on a systematic approach used with the indigent population of Dallas County.

Parkland Demographics

Parkland Memorial Hospital in Dallas has the third highest number of deliveries in the country. Of the approximately 15,000 annual births, 12.2% are low birth weight, and 2% are very low birth weight, which is double the national average. Of these LBW mothers, 40% are 17 years or under, and 11% are aged 13-16 years; 56% of the mothers have less than 12 years of education, and 57% are not married. The race breakdown at Parkland in 1988 was as follows: black 51%, white 23%, and Hispanic 26%.

Among the Parkland Hospital VLBW population, 58% require mechanical ventilation and 40% show signs of intraventricular/periventricular hemorrage on routine sonography.

PREDISCHARGE ISSUES

Typically a baby with a birth weight of 1500 grams or less stays in the hospital two to three months. The average visitation rate per baby in the Parkland NICU has been estimated to be one visit every 2-3 days, with some babies having significantly fewer visitors. The major reason parents and family members give for infrequent nursery visits are transportation and domestic problems. NICU nursery personnel, in an effort to make visitation more feasible, have taken the following steps:

- Allowing sibling visitation privileges in the Continuing Care Nursery.
- Providing overnight accommodations for parents.
- Encouraging and promoting infant-parent interaction during feeding.
- Scheduling discharge classes for parents evenings, weekends, and mornings.

Despite the staff's friendly attitude, a great number of mothers have never attended the discharge class and, until recently, 15% never kept their VLBW infant's initial follow-up appointments at Children's Medical Center. On occasion, Child Welfare is called before discharge to investigate a family that is deemed to be at risk for abusing or neglecting the NICU graduate. As one caseworker described, it is very frightening to send the medically vulnerable infant home to a family that has already had children removed or is likely to neglect this new infant. If the mother does not wish to relinquish parental rights, the caseworker must allow the infant to go home and then must wait for the family to abuse or neglect the infant before taking further legal action. Psychometric examination of the mother is not required before discharge in spite of the fact that subsequent psychiatric evaluation done in follow-up has shown a number of mothers to be suffering from depression, personality disorders, drug problems, and a variety of other psychiatric factors that predispose a person to dysfunctional parenting.

Need for Post-Discharge Intervention

Desmond et al. (1980) have described in detail the medical problems the VLBW infant can encounter. After nursery discharge the problems of the VLBW baby do not disappear but instead remain as the tip of an iceberg that often does not become evident until several months or years later, when the child is of school age. Considering the multiple problems that are likely to be encountered by the NICU graduate, it is important to determine if a systematic comprehensive follow-up program can prevent, or at least partially alleviate, a number of vulnerabilities. In order to maintain the spectacular success levels accomplished by the neonatologists and nurses in the Level III nursery setting, health care professionals must make an equally intensive effort after discharge, particularly among the indigent clientele. At present, 7% per year of VLBW infants expire after nursery discharge; 10% of these deaths are due to pneumonia. The rate of rehospitalization within the first year of life, according to a study by Hack et al. (1981), is 33%; we have found the same incidence at Parkland Memorial Hospital. Of significance is the number of cases of failure-to-thrive infants for psychosocial-related reasons.

The *1983 Guidelines for Perinatal Care* (Brann) have confirmed this need for high-risk neonatal follow-up care, which includes VLBW infants. "Follow-up programs are an integral part of regional perinatal care systems; they provide a base for outcome, evaluation, and research." Neonatologists involved in follow-up care acknowledge that what they do in the NICU is very much affected by what they see in their follow-up clinics. In Dallas, this reciprocal relationship has led the Department of Neonatology at the University of Texas Southwestern Medical Center to develop a three-year neonatology fellowship, with emphasis on follow-up of NICU-VLBW graduates.

General Approach

The 1984 report of the Texas Task Force on Indigent Health Care recommended state-wide high-risk infant follow-up procedures. To date no state-wide follow-up system exists in Texas, but other states, including Florida and Pennsylvania, have developed a regionalized system that covers all NICU graduates. In Texas, the Task Force goals for high-risk follow-up are as follows:

- To assure that infants at risk for developmental delays and other handicaps have the maximum opportunity to reach their developmental potential.
- To enhance infant health care for those at risk, through a system of identification and tracking, to assure that all high-risk infants remain under child-health supervision by a private physician or public health clinic, at

least for the first year of life. Appropriate referrals could include such services as Crippled Children's and Early Childhood Intervention.
- To reduce the incidence of child abuse and neglect in this high-risk population.
- To reduce the cost of hospital care by preventing subsequent hospitalizations and unnecessarily long stays for socioeconomic reasons.

Table 1 shows an adaptation of the Diagnostic Assessment Timetable from the American Academy of Pediatrics Committee on the Fetus and Newborn.

Table 1

Diagnostic Assessment Timetable—First 24 Months*

Age	Metabolic Screening	Physical Growth	Neurologic Assessment	Ophthalmologic Assessment	Auditory Exam	Bayley Scales**	Behavioral Questions
Birth	+	+	+	+	+		
6 mo.		+	+			+	+
12 mo.		+	+	+	+	+	+
24 mo.		+	+			+	+

* Adapted from *1983 Guidelines for Perinatal Care.* American Academy of Pediatrics/American College of Obstetricians and Gynecologists. 1983.
** Bayley, N. 1969. *Bayley Scales of Infant Development.* New York: The Psychological Corporation. 1969.

A follow-up program utilizing this timetable would, it is hoped, prevent—or at least alter—some of the medical vulnerabilities of VLBW infants. The perinatal guidelines explicitly describe the importance of calling to mind the psychosocial factors associated with child abuse, specifically prematurity, unmarried teen mothers, prolonged NICU stay, and infrequent visitation by families in the nursery.

Dallas LBW Clinic: A Specific Model for Follow-Up Care

Recognizing the staggering problems of the LBW infant from an often high-risk family, the follow-up program offered to infants born at the Parkland Memorial Hospital is comprehensive.

Using Dallas community resources currently available, the LBW Clinic offers comprehensive medical and social follow-up for the Parkland Memorial NICU graduates with birth weights of 1000 grams or less and for those infants with birth weights of 1000-1500 grams who require mechanical ventilation.

Currently 300 families are enrolled and are maintained in the program until the baby is 18 months of age. According to Dr. Saigal (1985), the first 18 months of life is a critical period that must be carefully monitored. Neurologically, this is the period of the brain's growth spurt. From a pulmonary standpoint, the first 18 months is critical for the infant with bronchopulmonary dysplasia. New lung tissue can grow, provided proper nutrition is maintained and the infant is kept from contracting respiratory illnesses. Retinopathy of prematurity may resolve or progress within the first year of life; regular ophthalmologic exams are needed to detect this or the common condition of strabismus. Routine follow-ups can detect posthemorrhagic hydrocephalus, if it occurs, within the first 18 months. Placement of a shunt may improve an infant's development. Seizure disorders, cerebral palsy, and sensorineural loss may all be diagnosed within the first 18 months. Neglect presenting as nonorganic failure to thrive may not become evident immediately but often can be documented by 18 months. Fractures of the long bones from abuse may not occur until after the toddler starts to ambulate. Finally, mild developmental delay or mental retardation may be difficult to diagnose with a fair degree of confidence until the latter half of the infant's first year and into the second year.

Follow-Up Clinical Procedures

While the mother of a baby eligible for the LBW Clinic is still on the maternity ward, a *VISTA volunteer* greets her. The interview includes a determination of the mother's transportation needs to visit her infant in the NICU and later to bring her baby to the LBW clinic. The VISTA volunteer records the risk factors and identifies admitted drug users, psychosocially overwhelmed mothers, and those who are socially isolated. Once identified, the high-risk family is assigned a Pediatric Nurse Practitioner (PNP) or Child Health Associate (CHA), who will serve as the primary caregiver to the NICU graduate. The caregivers encourage the mothers to attend the LBW follow-up clinic and offer tours of the follow-up clinic. By establishing a rapport with an inpatient mother, the allied health professional is able to encourage frequent nursery visitations, which are recorded by the NICU nurses. At the time the NICU graduate is discharged, the family is made well aware of the follow-up program offered at Children's Medical Center.

Foster grandparents provide role models at home and at the clinic.

After connecting with the PNP/CHA, the mother receives a visit at home from the *public health nurse* shortly before the infant's scheduled discharge. One of the purposes of this call is to assess the physical environment in which the infant will be placed. A Maternal Support System Scale is determined at this first home visit. (See Appendix.) The PNP/CHA makes a second home visit, to assess the mother's ability to handle the new arrival, within a month after the infant has been examined in the LBW Clinic.

Approximately 10 days after nursery discharge, the infant is seen in the LBW follow-up clinic. If the mother expresses the desire for help, she is assigned a *foster grandmother,* funded by the government agency ACTION, to visit her

Tracheostomies may be necessary with bronchopulmonary dysplasia (BPD).

several times a week. The infant receives a careful neurological exam, a developmental screen (the Denver Developmental Screening Test), and a routine examination by the attending *pediatrician* or *neonatology fellow,* who supervises the PNP/CHA. Depending on the infant's condition, members of the multidisciplinary team may be called upon to assess and aid the mother and infant. A *nutritionist, occupational therapist, social worker,* and *neonatologist* are present to assist. At 9 months, the Bayley Scales of Infant Development are administered by the *research nurse.* An *ophthalmology* appointment is made on the first visit, and subsequent appointments are monitored to assure compliance. Routine head sonography for intracranial hemorrhage is done according to protocol. Infants with birth weights less than 1000 grams or with extensive bowel resection following necrotizing entercolitis are worked up for rickets. Evidence of cerebral palsy is usually present by 6-8 months adjusted age, and referral to an appropriate intervention program is arranged. The *attending pediatrician* gives close medical attention to the infants with severe bronchopulmonary dysplasia and to those with seizure disorders. Inguinal hernias are the most common problem referred to the *outpatient surgery* clinic

and are generally repaired by 6 months adjusted age. Abuse and neglect cases are shared by the *Abuse and Neglect Clinic* and the *LBW Clinic*. Many *ENT* (ear, nose, and throat) referrals for chronic serous otitis media are made in the child's second year. Failure to thrive, viral pneumonia, rule-out sepsis, and reactive airway disease are the most common reasons for hospitalizing LBW babies. Because of the pertussis threat, and the fact that the graduates of a few other NICUs at other centers have expired from whooping cough, the LBW Clinic immunizes at 2, 4, 6, and 18 months chronological age in compliance with the AAP recommendation. Infants on anticonvulsants with post-neonatal asphyxia need careful consideration. The immunization for pertussis may

Some developmental "catch up" may occur following marked clinical improvement of the respiratory system.

exacerbate a seizure disorder, and this risk must be weighed; a neurologist may need to be consulted. The flu vaccine is given to LBW babies with bronchopulmonary dysplasia, 6 months and over, in two doses every fall.

Psychiatry fellows provide a weekly parent support group that is usually well attended. Most parents find this group helpful. Several mothers have been diagnosed as being depressed; these mothers have been referred for more extensive psychiatric help. Mothers with more involved psychiatric problems are referred to the Parkland Memorial Hospital *Adult Psychiatric Clinic* or inpatient unit.

All parents are given a 24-hour number to call to receive emotional support or to seek pediatric medical advice. At least half a dozen mothers have been suicidal and wanted to give up their infants. The LBW Clinic provides a liaison between the psychiatric emergency room and the mother. Ill infants are seen in the *Acute Care Clinic* at Children's Medical Center. The LBW staff make every effort to call ahead to the emergency room to alert the resident on call. The

effort to call ahead to the emergency room to alert the resident on call. The LBW Clinic provides the families of patients with a special booklet printed by Ross Laboratories. It briefly describes the NICU graduate's neonatal course and subsequent history. This booklet is filled out by the examiner at the first visit and is given to the mother, who is instructed to bring it with her whenever the child sees a doctor. The booklet provides the emergency room physician with a baseline respiratory rate and description of the present condition of the bronchopulmonary dysplasia patient.

Because almost half the mothers who attend the LBW Clinic have dropped out of high school or even junior high school, a *social worker* writes up "Life Plans" for each mother and gives her a partial short-term goal. Many teenage mothers have successfully returned to school to complete their high school education. Emphasis is placed on preventing the single teen mother from getting pregnant a second time and having another high-risk infant. The social worker and foster grandparents have been extremely helpful in identifying abuse and neglect and making *Child Welfare* referrals. A special home that accepts both mother and NICU graduate for an extended time has been set up to assist the homeless high-risk mother-infant pair.

The LBW Clinic serves as a research site for the eight-center collaborative *Infant Health and Development Program Study* as well as providing ongoing research for the neonatology department to follow up. Finally, the LBW Clinic provides a training ground for a variety of health and education professionals in allied medical fields. Pediatric residents benefit from the detailed neurological examination and method of referral for suspected cerebral palsy or developmental delay; when these physicians enter practice, they often find their well-baby care includes a number of NICU graduates.

When the child is ready for discharge from the LBW Clinic, the staff completes the Graduate Form (see pages 133-134) to inform others who will come in contact with the child.

Acknowledgments

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LBW CLINIC GRADUATE FORM

Date_____ Name_____

Born at_____ Race_____ Sex_____ MR Number _____

NICU Summary: Birth: Vag / Csec Weeks_____ AGA SGA LGA Weight_____Birthday _____

Apgars____ Ventilated____ Seizures____ BPD____ Surgeries_____

_____

_____

_____

Family History _____

Hospitalizations _____

Surgeries _____

Medical Problems _____

Current Medications_____Last Level: Date_____Result_____

_____

Significant Lab, X-ray, or Special test dates and results _____

_____

Rickets: Yes No Resolved: Yes No

Immunizations: DDT/DT_____ OPV _____ MMR _____ Other _____

_____ _____ Next Immunization due:_____

_____ _____ PPD: Date_____

_____ _____ Ophthalmology _____

Allergies_____ _____ ROP Yes No

Last PE Date_____ Wt_____ kg_____% Assessment of Growth _____

Ht_____ cm_____%

Foc_____ cm_____%

Code: ✓ normal, x abnormal, — deferred

☐ General ☐ Skin/Hair ☐ Head ☐ Eyes ☐ Ears ☐ Nose ☐ Chest/Lungs

☐ Mouth ☐ Heart ☐ Abdomen ☐ Genitalia ☐ Extremities ☐ Neurologic ☐ Development

Comments _____

_____

_____

_____

_____

_____

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Bayley Scales of Infant Development: Date of test _____

Chronological Age:_____years _____months _____days

Adjusted Age:_____years _____months _____days

	Age Equivalent	Index	Index Adjusted for Prematurity
Cognitive			
Motor			

Names of Other Clinics and Agencies involved:

_____Date of Next Appointment_____

_____Date of Next Appointment_____

_____Date of Next Appointment_____

_____Date of Next Appointment_____

Child Welfare: _____Yes _____No

Caseworker_____

Phone #_____ Ext_____

Social Problems:____ Low Risk____ Medium____ High

Low Birth Weight Clinic attendance:_____Good _____Fair _____Poor

Address of Baby: _____

_____

_____

Contact Person: _____

Address: _____

Phone:_____

Mother:_____

Address:_____

_____

Phone: _____

Work Phone: _____

Father:_____

Address: _____

_____

Phone:_____ _____

Work Phone:_____

Needs to be seen again:_____For: _____

Referred to: _____

Report prepared by:_____Phone: _____

Low Birth Weight Clinic Graduate Form
Children's Medical Center of Dallas
1935 Motor Street
Dallas, Texas 75235

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Nutrition and Feeding Screening: A Practical Guide

by Delia Solis, M.S., R.D., Lyla Chustz, O.T.R., Catherine McCarty, M.S., R.D., and Lori Stotko, B.S.

NUTRITION OF THE INFANT

Definition of Terms

Total Parenteral Nutrition: Intravenous feeding of specially prepared solutions.

Enteral Nutrition: Feeding of specific products/formulas by mouth or by tube (gastric, naso, or oral.)

Premature Infant Formulas: Formulas that have been specially formulated to meet the nutritional needs of the premature infant. They are *not* usually available outside the hospital setting.

Hyperalimentation: See total parenteral nutrition.

Feeding the Infant: General Information

Zeigler (1985) stated in a study that "the monitoring of nutritional status and nutrition counseling should be made a part of the routine follow-up care of premature infants."

Nutritionally, infants of low birth weight usually present with special needs and problems of varying complexities. It has been well documented by Ziegler et al. (1981), Owen (1983), O'Leary (1985), and the Committee on Nutrition, American Academy of Pediatrics (1985), that the immature gastrointestinal tract is unable to accept and digest adequate quantities of food. Parenteral feedings in the early nutritional support of the LBW infant help solve this

problem by providing satisfactory amounts of most nutrients. As the infant's gastrointestinal tract matures and weight gain proceeds according to protocol, enteral feedings, such as premature formulas or mother's preterm milk, gradually replace parenteral feedings.

Ziegler (1985) observed that premature infant formulas are commonly discontinued when the infant reaches 2000 to 2500 grams, prior to hospital discharge. Routine practice thereafter includes feeding the infant a standard 20-calorie-per-ounce infant formula or human milk.

Foman et al. (1979) and Illingsworth and Lister (1964) noted that nationally accepted recommendations for feeding term infants suggest that human milk or formula should be offered throughout the first year of life. Solid foods should be delayed until the infant's consumption of food is no longer a reflexive process and the infant has the fine, gross, and oral-motor skills to appropriately consume solids. This usually occurs at 4 to 6 months of age. Textured foods (mashed or finely chopped table food) can be introduced at 6 to 7 months of age, when an infant is developmentally ready to try to chew.

These recommendations are based on three important considerations: (1) nutrient needs, (2) physiological needs, and (3) overall developmental capabilities of the term infant. The same considerations are also present when addressing the appropriate time for the introduction of solid foods in the diet of the LBW infant. For example, the 5-month-old baby girl who was born 10 weeks premature (or 2½ months old corrected age) may not have the necessary oral reflexes or trunk control to accept food from a spoon. Thus this infant is not developmentally ready for this task.

The need for guidelines for feeding LBW infants is evident from the findings of Ernst et al. (1983), who conducted a study of feeding practices of 89 very low birth weight infants in the first year of life. Three prevalent practices potentially resulted in compromised nutrition for these VLBW infants: (1) cereals were introduced at an early age, (2) 2% fat milk and skim milk were fed to approximately half the infants within their first year of life, (3) whole cow's milk was introduced to some VLBW infants at an early age.

Gastrostomy-fed children require careful monitoring of their nutritional status.

The literature offers no evidence of comprehensive study of the nutritional status of LBW infants after hospital discharge. Ziegler (1985) indicates that studies need to address the mineral needs of these infants, particularly zinc, copper, calcium, and phosphorus. The possibility of depletion of these nutrients in the LBW infant after hospital discharge may depend on the severity of the complications experienced during the neonatal period.

Until such studies are designed and completed, it is important that health care providers consider ongoing monitoring of the appropriateness of the LBW infant's dietary intake. This monitoring is based on the recommendations noted above, not only immediately after hospital discharge but also through the first year of life.

The information in the following two sections of this article deals with important areas of concern for the LBW infant—feeding skill development and growth assessment. The intent is to provide complete yet practical information to guide you in identifying problem areas and in making appropriate referrals. The last section of this article, the Infant Nutrition Screening Form, puts this information together in a concise format. The form may serve as a useful tool in the monitoring of the LBW infant.

FEEDING SKILLS DEVELOPMENT

Definition of Terms

"Bird" Feeding: Pushing food or pouring liquid into a child's mouth while the head and shoulders remain back. This is often seen with improper positioning techniques. Adequate swallowing is very difficult in this position and the risk of aspiration of liquids or foods is high.

Bite Reflex: A strong closure of the jaw when the teeth or gums are stimulated. It is often difficult for the child to release the bite and open the mouth after this reflex has been elicited. Attempts to remove a spoon during the bite reflex result in a stronger closure of the jaw.

Drooling: Flow of saliva due to poor lip closure, sluggish swallowing, poor tongue control, and poor oral muscle tone.

Gag Reflex: A lowering of the jaw with forward and downward movement of the tongue and pharyngeal constriction upon stimulation of the posterior half of the tongue or pharyngeal area. This reflex is present at birth; it reduces in strength at approximately 7 months of age, but it persists in some degree through adulthood.

Jaw Thrust: A strong downward extension of the lower jaw. It can occur when the food is presented or while the food is being handled in the mouth.

Mashed Foods: Semisolids with a slight texture. Foods can be mashed with a fork.

Munching Pattern: Up and down motion of the jaw.

Non-nutritive Sucking: Generally the sucking period is of short duration followed by a rest period and then back to sucking. Leonard et al. (1980) noted that the respiration-to-suck ratio is 1:1 in nutritive sucking and 2:1 in non-nutritive sucking.

Nutritive Sucking: Sucking for the purpose of obtaining liquid. The sucks are generally longer and are in bursts of 50-200 sucks.

Pureed Foods or Semisolids: Foods that are blended and have a smooth, thick consistency.

Rooting Response: Head-turning in response to tactile stimulation applied to the lips or facial area surrounding the mouth. It appears in normal infants until about 4 months of age (longer if breastfed). The strength and degree of response also depend upon the state of the infant (hungry, sleepy, just fed).

Rotary Chewing: Up-and-down and side-to-side motions of the jaw. A circular motion.

Solids: Foods that have not been reduced or softened, such as roast beef, cheese, vegetables.

Sucking: A rhythmical method of obtaining liquid characterized by up/down tongue movements, tongue-tip elevation, greater lip approximation, minimal jaw excursions, and negative pressure in the oral cavity.

Suckling: Early lick-type infantile method of sucking characterized by forward/backward tongue movements, large up/down jaw excursions, and loose lip approximations.

Thickened Liquid: Liquids thickened with cereal, pureed fruit, or other substances that make them less fluid.

Thin Liquid: Water, juice, or milk.

Tongue Lateralization: The movement of the tongue to the side of the mouth.

Tongue Thrust: An abnormal involuntary forward-thrusting movement of the tongue from the mouth. The thrusting of the tongue may make it difficult to insert the nipple or spoon into the infant's mouth or may cause the tongue or food to be pushed out during feeding.

Weak Sucking: A sucking or suckling pattern in which the nipple can be consistently pulled out of the mouth easily.

Fanaroff and Klaus (1986) observed that the development of feeding skills depends upon the maturation of the central nervous system, which controls the acquisition of fine, gross, and oral motor skills. Each of these influences the infant's ability to consume food and to suckle, suck, chew, and swallow.

These investigators also found that the coordination of the suck/swallow mechanism develops at approximately 32 to 34 weeks gestation. This mechanism is not fully developed until after birth. The "mature suck/swallow pattern" consists of prolonged sucking bursts with multiple swallows occurring simultaneously with sucking. In immature infants, the suck pattern is demonstrated as short sucking bursts that are followed by swallows. This suck pattern continues for some time in the immature infant; it may indicate that it is a developmental protective mechanism that prevents overloading of the esophagus.

This infant looks content after a feeding. If the child has a tube, it is important to encourage non-nutritive sucking by the use of a pacifier.

Shivpuri et al. (1983) noted that orally fed preterm infants from 34-38 weeks showed decreased ventilation during continuous sucking.

When presented with a stimulus, infants first "mouth" the nipple before making sucking attempts. Sucking varies with nipple flow and the type of food. Research by Rybski et al. (1984) indicates that infants learn proficient sucking over a period of time.

Bernbaum (1983) found that a program of oral stimulation may be very beneficial for infants being fed by tube and orally. A tube-fed infant should also suck a pacifier. This appears to accelerate the maturation of the suck reflex and results in a more rapid transition from gavage feeding to oral feeding. There are other demonstrable benefits as well. There is often a decrease in muscular activity during feeding because of pacification and other factors that influence digestion.

Psychomotor and reflex actions indicate that the infant is more likely to accept spoon feeding after 4 to 6 months of age. Prior to this time, the infant will have a predominant sucking and tongue protrusion reflex. Individualize the addition of pureed foods to an infant's diet. Never force food on an infant.

The important prerequisites for independent feeding include:

- Adequate head control.
- Good sitting balance.
- Functional upper extremities.
- Adequate control of jaw, lips, and tongue.
- Adequate bite, chewing, sucking, swallowing, and coughing.

The progression of feeding in the infant is dependent on a developmental and physiological readiness for specific foods and food textures. The feeding progression scale in Table 1 summarizes this development in the LBW infant, but use it only as a guide in assessing an infant's feeding skill level.

Table 1

Feeding Progression Scale

CHRONOLOGICAL AGE	FEEDING SKILL	FOOD CONSISTENCY
Newborn to 6 months	Rooting reflex, bite reflex, suck-swallow pattern, protrusion-retraction movements of the tongue or tongue thrust.	Nutritional needs are met by breast milk or formula via bottle.
6-8 months	Anticipates food and opens mouth for the spoon with good head and trunk control; up and down chewing movements upgraded. Elevation/depression movements of the tongue; bites soft foods and holds bottle.	Pureed foods: plain yogurt, pureed cottage cheese, dry infant cereal.
8-10 months	Independent sitting, bite reflex disappears, begins finger feeding and cup drinking.	Semi-solids, mashed table foods, graham crackers, Melba toast, teething biscuits, mashed egg yolk, and cooked vegetables.
10-15 months	Finger feeding with lateral tongue movements; begins rotary chewing and cup drinking, but may spill. Begins self-feeding; number of bottles should decrease.	Soft-cooked vegetables, fruits, meats, cheese strips, dry cereal, macaroni, scrambled eggs.
15-18 months	Self-feeds, drinks from a cup.	Regular table foods, bite size appropriate for age and number of teeth.
2 years	Spoon feeding refined, good rotary chewing.	Same as above.

Connor et al. (1978) observed that the introduction of solid food to the diet of the term infant is generally later than 4 months chronological age because it takes at least that long for the infant to develop adequate suck-swallow skills. Thus it may be appropriate to wait until 4 months adjusted age in the preterm baby to introduce solids. Earlier introduction of solid foods may also compromise an already small feeding volume.

Note that some feeding skills depend on appropriate dental and oral development. Morris (1983) observed that "the eruption time of primary teeth is apparently not associated with prematurity. It is known that prematurity can cause enamel hypoplasia (poor development of the enamel). This is thought to be from the trauma of transition at birth interrupting enamel deposition and calcification." Nowak and Erenberg (1984) observed that the preterm infant's possible state of calcium deficiency in the early period after birth may also contribute to enamel hypoplasia and to palatal groove formation with the long-term use of orotracheal intubation.

Defective primary dentition associated with long-term use of orotracheal intubation in preterm infants has been reported by Moylan et al. (1980), Nowak and Erenberg (1984), and Seow et al. (1984).

There is a need for more studies on the development of the oral cavity in preterm infants to determine what, if any, problems they may encounter in later years as a result of the long-term use of orotracheal intubation.

Articles on Feeding

Feeding small preterm infants requires different techniques than does breast- or bottle-feeding a term infant. Term infants demonstrate a higher sucking frequency, a more well-defined suck-pause pattern, and a higher minute-consumption of formula than preterm infants. Jain et al. (1987) observed that preterm infants expend more energy to suck the same volume of feed, but their suction power is weaker, possibly because of incomplete neurologic maturation of buccal, tongue, and palate muscles.

Studies show that stable preterm infants may respond more favorably to breast-feeding than to bottle-feeding. In a study by Meier and Anderson (1987) involving five preterm infants over a period of 71 feedings, the infants tended to show fluctuations in sucking patterns when feeding from a bottle. Breast-feeding promoted longer feeding sessions in preterm infants. They also showed better coordination of sucking and breathing and a concurrent rise in body temperature. This rise in body temperature happens presumably because of the close contact with the mother's body. The faster milk flow and faster feeding time that occurred during bottle-feeding resulted in increased gastric distension and instances of bradycardia.

Routine techniques that help the new mother breast-feed correctly can also incorporate teaching the preterm neonate to suck correctly. An accepted proper positioning for breast-feeding the term infant is to hold the infant at a 45-degree angle, with the baby's face turned towards the mother. The mother holds the breast far enough behind the areola to ensure that her fingers are not in the way. In this position, at least an inch of breast tissue behind the nipple can fit into the baby's mouth. Marmet and Shell (1984) noted that the sucking response can be approximated by inserting a finger (pad toward the baby's palate) and feeling for a strong, cupping motion of the tongue that rolls back, compressing the finger against the palate. This is the proper milking motion that should occur. Swallowing should take place after every ripple, or after several sucks.

The vacuum formed by the normal infant's mouth against the breast is generally strong enough to ensure that the baby cannot be pulled away from the breast easily. The neonate or preterm infant may have a weak suck or faulty tongue movements that waste energy and prevent optimal amounts of milk from getting in. Basic training techniques include stroking the baby's lips, massaging the gums for oral stimulation, and rubbing the hard and soft palates with your finger inserted (pad up) to initiate sucking. If the infant's tongue fails to cup properly and does not press your finger to its palate in a milking response, insert your finger (pad down) to stroke the tongue and pull it forward. Dipping your finger in formula or using an eyedropper for this technique provides a reward to the infant for moving its tongue correctly.

Marmet and Shell observed that there are two possible incorrect tongue positions the infant can assume: (1) keeping the back of the tongue pulled up, thus reversing the normal wave-like motion from the back to the front of the mouth, and (2) keeping the tongue on the roof of the mouth, which prevents insertion of the nipple. Both problems can be resolved by using your finger to flatten the tongue down and pull it forward in the mouth. This encourages the tongue to assume a low, forward position that is ideal for cupping the nipple and trapping it against the palate in the milking motion.

Training mothers to breast-feed and to recognize correct and incorrect sucking patterns may be best carried out by pediatric nurses. A study conducted by Oates and Lilburne (1987) in Camperdown, Australia, showed that out of 342 health professionals who dealt with children, the pediatrically trained nurses were the best resources for mothers seeking advice about what formulas to use, about switching formulas to prevent or diminish colic, and about the advantages of breast- or bottle-feeding a particular child. Nurses gave consistently correct answers about feeding positions, optimal sucking, and formula concentration and temperature.

Problems in feeding infants can extend beyond the mechanics of correct sucking and swallowing. Aspiration of formula is the main concern when dealing with infants who seem to have recurrent chest problems. McVeagh et

al. (1987) used barium swallows and radionuclide milk scanning to test what happens to the formula after the infant swallows it. Both techniques are good indicators of the presence of gastroesophageal reflux, a major cause of aspiration.

The study by McVeagh et al. in Sydney, Australia, involved 120 infants. A gamma camera scanned radioisotope-tagged milk both immediately after and two hours after feeding, to find signs of aspiration. Reflux was considered severe if the milk reached the pharynx, moderate if it reached the middle esophagus, and mild if it reached the lower esophagus. This method proved to be more sensitive in recording reflux than did the barium-swallow films.

McVeagh et al. used barium swallow films with 96 infants. Results were obtained by X-raying each patient during swallowing and looking for evidence of abnormal swallowing, tracheal aspiration, anatomic abnormalities, and gastroesophageal reflux.

General Feeding Suggestions for Infants and Children

Refer an infant who presents with delayed progression of feeding skills to a feeding specialist for a more in-depth feeding assessment. This may be an occupational, speech, or physical therapist. Refer to the Appendix for an example of a questionnaire for obtaining a complete feeding history and identifying specific problem areas in oral feeding skills.

When you counsel caregivers about feeding their infants or children, it is important to stress that this should be a pleasurable experience for both the caregiver and the child. It also provides the baby with a major connection to the environment. Although the sensory needs of an infant—particularly an LBW infant—at feeding time are unknown, factors related to handling and techniques of feeding may subsequently influence the child's development.

Feeding an infant, particularly a medically fragile or physically challenged infant, may be one of the most delicate roles the follow-up professional assumes. Although normative video swallow studies are available for adults, very little information exists about the swallowing capabilities of babies. At best, a feeding specialist can attempt to observe the postural and oral mechanisms of a baby before introducing oral feedings. It is not possible to visualize whether or not aspiration is occurring during a bedside examination, except with a baby whose trachostomy can be suctioned to look for evidence of aspiration of colored formula. Until normative data are available, and video-swallow or ultrasound studies of high-risk neonates are routine, it may be advisable to obtain medical clearance before orally feeding any high-risk neonate where swallowing and aspiration are a major concern. Feeding involves significant legal as well as clinical implications. Some parents file

lawsuits when they disapprove of their baby's treatment. It may be advisable for feeding specialists to attend workshops on current issues in swallowing assessment and treatment.

The following recommendations may be useful when counseling with parents or other caregivers about any of the following considerations: general feeding, positioning of a small or handicapped infant during feeding, treating an infant with a poor suck, and feeding a child with cerebral palsy.

RECOMMENDATIONS

1. Generally keep infants under 4 months adjusted age on liquids only. Oral mechanisms and the digestive system are not mature enough for the infant to handle foods at an earlier age.
2. Do not prop the bottle and do not put the infant to bed with a bottle because the baby could choke and formula remaining in the mouth could cause tooth decay.
3. If the infant takes longer than 30 minutes to complete a bottle, a referral to an occupational or speech therapist or other feeding specialist may be required for an evaluation of suck/swallow and other oral mechanisms. Slow feeding may indicate inadequate suck or swallowing problems, which may lead to poor weight gain.
4. When bottle feeding an infant who is just learning to suck and to swallow, it is helpful to place most of the nipple in the baby's mouth. This seems to encourage sucking.
5. To feed adequately, the infant must be free of respiratory distress and must have an adequate suck-swallow reflex. (The infant's ability to suck and swallow adequately is not necessarily related to age and size.) This helps to provide for the infant's nutritional needs and prevents the risk of aspiration. Babies who show decreased ventilation during continuous sucking may need to have the bottle removed intermittently to allow recovery of oxygenation.
6. Burp infants halfway through a feeding and after a feeding. Put the infants on their stomachs on their caretakers' laps, or place them in a sitting position with the caretakers' hands on the upper chest and the infants leaning slightly forward. Use gentle pats on their backs. This helps prevent abdominal discomfort and decreases the possibility of spitting up.
7. If an infant is having difficulty maintaining closure on the nipple, apply jaw control. Keep the infant in an upright position. Do not use fast-flowing liquids from a nipple with an enlarged hole, because this does not require the infant to suck and may encourage abnormal swallowing or aspiration.
8. Offer finger foods when the infant can sit with good balance in a highchair. When they can sit upright, infants are ready for more advanced hand skills, and their oral mechanism may be ready for solid foods. Delaying the introduction of solid foods beyond 6 to 8 months adjusted age may present some serious problems in the babies accepting these foods.
9. Make certain the baby is ready to eat—calm and quiet but awake and alert.

This will help avoid conflicts about eating and will keep the experience pleasant.

10. Know the infant's oral-motor capabilities as well as the corrected gestational age. Some babies have a tongue thrust that forces the food out of the mouth; others have a bite reflex that causes them to bite down on the spoon or nipple each time it is placed in the mouth. It is important to know if these activities are voluntary or reflexive.

This child displays a readiness for finger feeding.

11. Be aware of your facial expressions during feeding time. Keep a pleasant demeanor even if it is not enjoyable to feed a child who chews with an open mouth or spits food out or drools. If your facial expressions seem negative, infants may think these feelings refer to them or the food. This makes mealtime unpleasant.
12. When introducing solid foods, put a small amount of the food on the spoon. This is particularly important for an older baby who has a tendency to push food out of the mouth with the tongue. It is more likely that babies spit out food when they have too much on the spoon.
13. Use a spoon with a shallow bowl. This encourages the infant to use the upper lip when taking food off the spoon.
14. Serve each food separately and not mixed with other foods. Mixing food deprives the infant of sensory cues of color, texture, and taste necessary for normal feeding.
15. When babies cough, do not slap them on the back; allow them to handle their own coughing. Slapping an infant's back may force food into the trachea.
16. Caregivers with babies who have a tendency to choke, and professionals who feed babies, should take the American Red Cross class on *Choking*. This ensures a knowledge of adequate management techniques for the caregiver if a child is not able to handle lodged food.
17. Refer to a physician if you suspect aspiration because of choking, feeding problems, or a history of repeated pneumonias. To evaluate the adequacy of an infant's swallow reflex and to determine if and why the infant is aspirating, referral for a video-swallow performed by a feeding specialist and a radiologist should be considered.

Feeding Positions for Small or Handicapped Infants

Developmental centers or early intervention programs should establish standards for feeding babies that might include the following: which babies require medical clearance, who on the team should feed the babies, and what minimal level of training the feeders should have.

RECOMMENDATIONS

1. Face-to-face: Sit in front of a table with a firm wedge or bed pillow resting partly in your lap. Place the infant on the wedge facing you. To provide head and trunk alignment, place a small pillow behind the baby's neck. The pillow supplies the necessary neck flexion to prevent head extension and shoulder retraction. The enface position may facilitate interaction between the caregiver and the infant. Be sure that the pillow is at the nape of the neck and not against the crown of the head. Elevating the caregiver's legs on a small stool or bolster provides extra support to stabilize the wedge. The face-to-face position can also be used with the baby placed in an infant seat with rolled-up towels, which provide substantial support.

   Let the baby's head bend slightly forward. Keep a preterm infant's head from falling too far forward to prevent an upper airway obstruction. Tilting the baby's head backward does not allow for the normal front-to-back method of swallowing. This also increases the likelihood of aspiration because the epiglottis does not effectively cover the trachea.
2. Held in arms: It feels natural to feed an infant in one's arms. However, some VLBW babies are too small to fit easily reclined over a parent's arm. These babies can be swaddled and supported on the parent's knees, face-to-face with the parent, or they can be placed with support in an infant seat. Reassure these parents so they will not feel guilty about not holding the child during eating. Maintaining the child in a semi-upright posture and providing the baby with good hip flexion to break up patterns of extension will encourage good body alignment.
3. Seated upright: Use an infant carrier in a nearly upright position. The infant's head should always be higher than the stomach. Place a towel roll under the baby's knees and position pieces of foam or small pillows to prevent the baby from leaning to one side. The towels and pillows encourage hip flexion and midline orientation that may make swallowing easier and safer.
4. The baby's head should usually not tilt back during feeding, but some babies with congenital abnormalities may need this position and require physician evaluation. This position enlarges the pharynx, allowing the liquids to funnel into the esophagus bird-style, a method that does not permit the infant to develop the normal front-to-back swallowing pattern. It also prevents learning how to coordinate breathing and swallowing. This position also increases the risk of aspiration. The head is likely to go too far back in a baby with bronchopulmonary dysplasia or a tracheostomy. If you bring the head forward, carefully watch to see that the infant can still

breathe freely. When the infant gains greater head and trunk control and is ready for a more upright posture, feeding can be done by sitting across the caregiver's lap. Adjust the angle of the infant's hips and give stabilization and support where it is needed by bringing your arm around the infant's back. Face-to-face sitting at this time provides the caregiver and the child with the opportunity for social and verbal interaction and eye contact.

5. Do not feed the infant lying down except when medically necessary. Lying down may increase the risk of ear infections and aspiration. The infant's tongue may not be in an effective position.
6. If strapping is necessary to maintain positioning, apply the straps across the infant's pelvis. A rolled towel or a reversed wedged pillow under the child's thighs will provide added flexion of the infant's hips. Provide whatever support is needed to maintain proper alignment. Flexion of the hips inhibits an extension pattern that can interfere with effective oral functioning.
7. While feeding the child, be in a comfortable, relaxed place with the food readily accessible. There are many variations of the "sitting in a chair" position. Try them and, if necessary, consult with a therapist or other person who knows what will work best. An appropriate position is one that allows the child to eat happily and easily but keeps the caregiver comfortable, too. This facilitates a positive feeding experience.

Feeding Infants Who Have a Poor Suck

RECOMMENDATIONS

1. Provide jaw control and masseter support. This helps to maintain a seal on the nipple.
2. Use a Nuk nipple. This encourages the infant's lips to maintain contact with the nipple by allowing the jaw to stay open wider than regular nipples can.
3. Use a pacifier to facilitate the infant's non-nutritive suck and to continue oral stimulation for non-oral feeders.
4. Help improve a weak suck by cuddling the baby in flexion (sucking is a flexion pattern). Putting your finger into the baby's hand to encourage a grasp reflex can also assist sucking. Apply gentle massage to the face.

Feeding Children with Cerebral Palsy

These recommendations are for "classic" cerebral palsy. In some cases, video-swallow studies may indicate that other techniques or positioning should be employed. The studies may reveal that some of these children should not be fed orally.

RECOMMENDATIONS

1. Consider poor sucking after a period of normal feeding a danger signal. Contact the child's physician. This may indicate a medical or neurological problem.
2. Introduce the rubber-coated spoon to the child from midline, in the front. Swallowing mechanisms are usually more effective with the head midline.
3. Allow the child to empty the mouth completely before presenting another bite. This decreases the tendency to thrust food out and is much easier for a child to handle.
4. Allow the child to swallow before blotting the lips. Lip blotting may result in suckling rather than swallowing.
5. Place the spoon on the child's lower lip and wait for the lip to come down. This encourages voluntary lip closure.
6. Assist lip closure when necessary by using your fingers to bring the child's lips together to remove food from the spoon. This encourages more adequate swallowing.
7. Place the cup on the child's lower lip, making sure the tongue is in the mouth or under the edge of the cup. Placement of the tongue in the cup results in suckling.
8. Use your thumb to help seal the child's lower lip against the cup if the child has difficulty doing this. This decreases the dribbling of liquid from the mouth.
9. Wait for the child to release the spoon, then pull gently if the child has a bite reflex. This may avoid reinforcing the bite reflex or damaging the teeth.
10. Push *upward* on the child's jaw to facilitate opening if a bite reflex is present. For a child with cerebral palsy, pulling *down* on the jaw or tugging the spoon out causes the mouth to close more and strengthens the bite reflex.
11. Move the child's jaw in a circular pattern to facilitate chewing textured food if the child fails to initiate this activity. Rotary chewing may be absent.
12. Do not scrape the food off the child's lips or chin. Scraping does not encourage voluntary lip closure and may set off other involuntary reflexes.
13. Do not feed a child who is crying or laughing. This may cause the child to choke and increases the risk of aspiration.
14. Do not present food from above the child's head. The child may tend to hyperextend the neck, resulting in the opening of the trachea and an increased risk for aspiration.
15. Do not mix solids with fluids to feed through a bottle or infa-feeder. Use a spoon to feed the baby solids. Mixing does not allow the infant to experience the texture and flavor of individual foods. The infa-feeder may hamper the development of appropriate facial muscles that are crucial for proper speech development.

GROWTH MONITORING

Definition of Terms

Accuracy: Degree to which a measure of a child corresponds to the child's actual weight or length (stature).

Anthropometry: Measurements of length or stature, head or arm circumference, weight, or other proportions of the body.

Beam Balance Scale: A weighing device characterized by having a set of sliding weights to counterbalance the object being weighed.

Length: Distance from the crown of the head to the bottom of the heels when the subject is measured *supine*.

Precision: Degree to which successive measurements of the same child agree within specified limits.

Recumbent: Lying down, on either the front or the back of the body.

Stature: Distance from the crown of the head to the bottom of the feet when the subject is measured *standing*.

Supine: Lying on the back.

Zeroed Scale: The condition of a scale being in balance when there is nothing being weighed and the sliding weights are directly over their respective zeros.

Introduction

Growth monitoring of low birth weight infants is an important component of the total nutritional care of these infants. It can provide important clues to the health and nutritional status of the infant. It also serves as an important method of documenting growth outcome in the low birth weight and very low birth weight population. Total body length and weight are the measurements most often used and thus provide the most useful information for:

- The identification of infants or children who have growth abnormalities.
- The determination of growth patterns in groups of infants or children.
- The evaluation of infants or children who are receiving treatment for a growth abnormality.
- The identification of either obesity or indequate weight gain in infants or children.

These measures can be determined by plotting length and weight for age, and weight for length. In assessing these measures, it is more useful to have a series of measures to determine each child's growth curve.

In practice, the accuracy and precision of these measurements are often unsatisfactory because of the deceptive simplicity involved in measuring length (or height) and weight. It is important to remember that *measurements are useful only if they are accurate.* Keep in mind when looking at some of the weight variability in VLBW neonate records that some of the measurements may have been taken with IV boards or other equipment attached to the babies. Following is a summary of the appropriate techniques used for measuring length (or height) and weight in infants and children.

Technique and Equipment

WEIGHT

Measure body weight with appropriate-sized beam balance scales. Do *not* use bathroom or spring-type scales. Two sets of scales are desirable: one set for infants and small children that permits reading to the nearest 1/2 ounce, and another set for older children and adults that permits reading to the nearest 1/4 pound. *Scales should be calibrated every three or four months.*

Always make measurements of weight without shoes. An infant should be unclothed when being measured. Young children should be unclothed or in undergarments only.

Infants or children who are extremely frightened or agitated may need to be weighed on an adult-size scale while being held by a parent; subtract the weight of the parent from the combined weight.

Take care in choosing a portable scale that has to be transported from one clinic site to another, or from one home to another. Careful calibration and adjustments on these scales need to be made often due to their frequent movement.

Metric Conversion: 2.2 pounds = 1 kg or 1000 grams; 1 ounce = 28.54 grams.

LENGTH OR HEIGHT

Always take measurements of length or height without shoes. During the first two years, measure length while the child is lying down rather than height while standing. This will continue with non-ambulatory children, or with children whose motor problems make it difficult for them to stand straight.

Measurement of length is difficult. Do not attempt it unless satisfactory equipment and two trained examiners are available. In many instances, it will not be practical to measure length routinely.

Figure 1 illustrates the method of measuring length. One person holds the infant's head positioned so that the line of sight is directly upward. Gentle traction is applied to bring the crown of the head into contact with the fixed headboard. A second trained person holds the infant's feet, knees, and hips completely extended, toes pointing directly upward and, also applying gentle traction, brings the movable footboard to rest firmly against the infant's heels. Do not measure an infant on an examination table by drawing a line at the head and feet and then measuring the distance between the two points. This is an inaccurate method of measuring infants and non-ambulatory children.

Children 24 months of age and older may be measured in the standing position (Figure 2). However, two examiners and much patience are usually needed to obtain standing measurements of children less than 3 years of age.

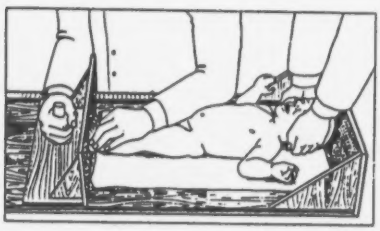

Figure 1

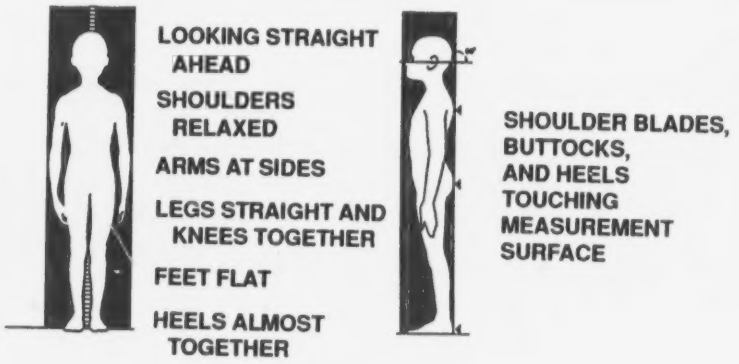

Figure 2

Do *not* use platform scales with movable measuring rods for measuring height at any age. Satisfactory equipment can be provided by fixing a measuring stick or tape to a true vertical flat hard surface, such as a wall. The child should stand on a horizontal bare floor with bare heels together, back as straight as possible, with the heels of each foot, buttocks, and shoulder blades touching the walls; the line of the child's sight should be horizontal. Bring a block, squared at right angles against the wall, to the crown of the child's head and note the measurement. Read the stature measurement to the nearest 1/8 inch.

Metric Conversion: 1 inch = 2.54 cm.

Summary

The following checklist should help in assuring accurate measurements.

WEIGHING

1. Remove all but minimal indoor clothing. If the infant is not nude, make sure the diaper is dry.
2. Zero the equipment.

3. When reading the weight on the scale, be sure that
   - The child is not moving.
   - The scale is in balance.
4. Confirm the weight by two readings that agree within 4 ounces before recording.

MEASURING LENGTH

1. Get an assistant to help in positioning the child.
2. Place the child in the supine position.
3. Correctly position the child so that:
   - The body is in line with the tape or yardstick.
   - The crown of the head is firmly touching the headboard.
   - The child's line of sight is at a right angle to the body.
   - The knees are pushed down and the body is fully extended.
4. Check that the heel(s) touch the footboard and the head touches the headboard while you are measuring.
5. Confirm the measurement by two readings that agree within 1/8 inch before recording.

MEASURING STATURE

1. Get an assistant to help.
2. Position the child's back against the measuring surface.
3. Correctly place the child so that:
   - The shoulder blades, buttocks, and heels are touching the wall or measurement surface.
   - The child's line of sight is at a right angle to the body.
   - The legs are straight and the knees are together.
   - The shoulders are relaxed and the arms are at the child's sides.
   - The heels are flat on the floor and the knees are not flexed.
4. Lower the headboard until it is firmly touching the crown of the child's head.
5. Confirm the measurement by taking two readings that agree within 1/8 inch before recording. There are various resources available to professionals to assist them in further refining the skill of accurate weighing and measuring. See the list of references under Growth and Nutrition Screening.

Recording and Plotting

It is important to use the correct growth charts when plotting length or height (stature). Growth charts for ages 0 to 36 months have been standardized for recumbent length, and charts for ages 2 years to 18 years have been standardized for standing height (stature). For non-ambulatory children older than 3 years of age, plot length measurements on charts for ages 2 years to 18 years. Note the method of measurement.

When plotting the preterm infant's measurements, remember to correct for prematurity (Figure 3). Take into account gestational age when interpreting growth status at birth or soon after. For example, place a 5-month-old infant born at 30 weeks gestation (or 10 weeks early) on a growth chart at 2½ months.

Practitioners often ask, "How long does one correct for prematurity on growth charts?" Moore and Roche (1983) noted that adjustments for prematurity should be applied until the ages of 21 months for weight and 36 months for length or stature. O'Leary (1985) noted that corrected age should be used in recording growth measurements until at least 12 months of age. She added that preterm infants who suffered severe medical complications or under-nutrition in the early postnatal period, and infants who were small for gestational age, may require a longer period of catch-up growth to reach their maximum potential for growth.

Plot a small-for-gestational-age term infant for chronological age. After plotting the measurements, determine the percentiles for each parameter from the chart, including length or height. Record these percentiles on the appropriate form. Note any adaptation to the techniques described above. For example, note if the right leg could not be extended and only the left leg could be extended and measured. Also, if there is a leg length discrepancy, be sure to note this and measure the same leg each time.

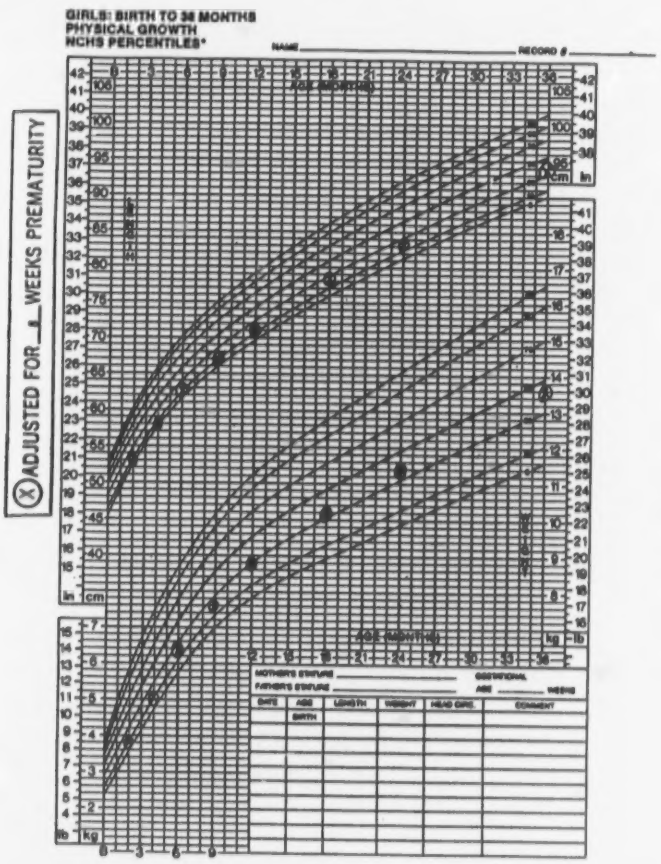

Figure 3

Assessment of Growth

After plotting these measurements it is necessary to assess whether the infant is growing appropriately. The evaluator must use judgment for the preterm or low birth weight infants who are below the 5th percentile, having not yet caught up to their term counterparts. If they are making progressive and consistent gains on their own curves, they require no nutrition referral, although continued growth monitoring by the primary care provider may still be indicated. If there is a rapid gain or drop-off, intervention by a nutritionist is necessary. Refer to the nutrition screening form in the last section of this article for other referral indications.

Summary

Any infant or child experiencing erratic changes or inadequate growth progressions deserves special attention. Assuming that the accuracy of the measurements has been established, watch closely a child between birth and 12 months of age with any of the following growth patterns:

- No increase in height or weight between monthly checks.
- Any decrease in weight.
- An increase of weight or length of more than 25 centiles between monthly measurements.
- An increase in weight or length of greater than 40 centiles in two months.

NUTRITION SCREENING OF LBW INFANTS

Screening for nutrition problems in the low birth weight infant population includes observation and assessment of three important areas:

- Dietary Intake
- Feeding Skills
- Growth

The Infant Nutrition Screening form included in the last section of this article is a useful tool for exploring pertinent information related to these three areas. The form was adapted from *Nutrition Screening for the Preterm and Term Infant*, Perinatal Outreach Education Program, Memorial Hospital, Long Beach, California. It is currently being adapted for use in the Low Birth Weight Clinic at Children's Medical Center (CMC) in Dallas, Texas. The CMC's LBW Clinic protocol for introduction of foods is based on *chronological age* for infants who

weighed between 1000 and 1500 grams at birth. Infants who weighed less than 1000 grams should be introduced to foods based on their *corrected age.* As noted earlier in this chapter, it is very important to consider the individual variations among infants regarding their developmental readiness for feeding. An infant who weighed 1200 grams at birth may not be developmentally ready at a chronological age of 5 months to be spoonfed infant cereals. This infant may need to be re-evaluated at a chronological age of 6 months to check on readiness for ingesting cereals.

This form can be adapted, with permission from the authors of the form, to the needs of other specific follow-up clinics for low birth weight infants. The reader is encouraged to contact the originator of the screening tool to obtain permission and receive current revisions. The address is in the References at the end of this article, under Morris, P. G. 1983.

Infant Nutrition Screening Form—Instructions

❶ PATIENT DATA SECTION

Record the patient data section and determine the infant's corrected age.

❷ FOODS SECTION

This section is organized so checks (✓) are placed only in the column under the month circled. Use the foods along with the words under "Assessment" as cues for questions to ask. The "Intervention" column provides direction about recommendations. After collecting all the data, use the last column on the right to determine if a referral is needed. Remember to use the infant's *chronological age* when screening for any kind of food intake if the infant weighed 1000-1500 grams at birth.

❸ SKILLS SECTION

Select the age or weight of the infant. Use the weight category until the baby reaches 4 months *corrected age.* If the infant is between categories you may want to ask questions from both categories. Be sure to gather all your data before giving feedback to the parents. The right-hand column is again used to identify problems. Refer to the section in this chapter dealing with Feeding of LBW Infants for in-depth information on the acquisition of feeding skills.

❹ GROWTH SECTION

It is important to measure the baby accurately because the measurements are only as useful as they are precise. In order to determine if the infant is shifting percentiles downward, serial measurements are necessary. If serial

measurements are not available, leave the question blank or write N/A for "not applicable." If any of the "yes" boxes are checked in the assessment section, it is necessary to make a referral. It is very important to follow the guidelines provided in the section on Growth Monitoring when assessing the growth of the LBW/VLBW infant.

Infant Nutrition Screening Form

❶ Name_____ Chron. Age - Wks. Premature = Corrected Age Date_____

Evaluator_____ ☐ ☐ ☐

❷ FOODS

Circle chron. age in months	1	2	3	4	5	6	7	8	9	10	11	11	12	Assessment Acceptable	Assessment Non-Acceptable	Intervention	Identified Problem ✓
Breast Milk: F/D____ Min/F____														Supplement Vitamins & Iron Brand:_____		Supplement Vitamins & Iron Brand:_____	☐
Formula: F/D____ oz/ F____ Total:____														Plain, iron, Iron Supplement Brand:_____		Formula with iron or plain with iron drops	☐
Water														Plain	Sugar, honey, Karo	Plain	☐
Infant Cereal														Spoon	In bottle or Infafeeder adult cereal	Spoon, infant	☐
Juices														Infant or Adult, diluted with vitamin C	Kool-Aid, Tang, soda, iced tea	Infant or Adult, diluted with vitamin C	☐
Fruits and Vegetables														Spoon	Strained food in bottle or Infafeeder	Spoon	☐
Meat, Poultry/Alt.														Spoon	Strained food in bottle or Infafeeder	Spoon	☐
Breads/Starches														Finger foods, toast, crackers, Cheerios	Sugar-coated cereals, cake, cookies	Dry toast, crackers, Cheerios	☐
Egg Yolk														Cooked yolk	Egg whites, whole eggs	Cooked yolk	☐
Snacks														Pudding, plain yogurt	Candy, chips, sweets	Plain yogurt, fruit	☐
Milk															Whole milk, nonfat milk	Formula to 1 year	☐
Fluoride Supplement?														Varies with water supply		If needed, refer to Physician	☐

☐ Food Groups can be introduced ■ Food Groups should not yet be introduced

Brand of formula_____ RTF Conc. Powder How mixed?_____ Correctly? Yes No ☐

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❷ SKILLS

Chronological Age/Weight	Formula/Food	Assessment		Intervention	Identified Problem ✓
6 lbs.	20-23 oz. formula	Completes bottle in 20-30 minutes? Holds baby while feeding?	Yes No Yes No	30 minutes: Evaluate suck-swallow. Encourage and demonstrate holding.	❑
12 lbs.	28-32 oz. formula	Completes bottle in 20-30 minutes? Holds baby while feeding?	Yes No Yes No	30 minutes: Evaluate suck-swallow. Encourage and demonstrate holding.	❑
5-6 mos.	30-32 oz. formula + cereal	Holds head upright? Food stays in mouth?	Yes No Yes No	Start solids.	❑
6-8 mos.	28-30 oz. formula + strained/mashed foods	Picks up small objects? Holds own bottle?	Yes No Yes No	Start finger feeding. Evaluate cup introduction.	❑
8-12 mos.	22-26 oz. formula + table foods	Drinks from cup? Eats lumpy food?	Yes No Yes No	Encourage self-feeding. Introduce table foods and textures.	❑

Problems with diarrhea or constipation? Yes No _____ ❑

Bottle taken to bed? Yes No _____ ❑

WIC Yes No _____ ❑

❸ GROWTH

Measurements	Assessment Lt. Wt., or Wt./Lt.			Intervention
NCHS Growth Chart	Falling off curve?	95%	Excessive gain	Refer
Corrected Lt. _____ _____% Wt./Lt._____%	❑ Yes	❑ Yes	❑ Yes	None needed
Corrected Wt. _____ _____%	❑ No	❑ No	❑ No	

Refer to Nutritionist if:

FOODS 3 or more identified problems
SKILLS Discretion of evaluator
GROWTH Referral needed, per above

OTHER _____

Comments: _____

_____

_____

_____

Referred to: _____ Date: _____

Adapted from *Nutrition Screening for the Preterm and Term Infant*, Perinatal Outreach Education Program, Memorial Hospital, Long Beach, California, by the Dallas Neonatal Network Nutrition Committee, 1986.

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*Denotes especially recommended reading.

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Instructions for Nasogastric, Oral Gastric, and Gastrostomy Tube Feedings

by Donna Linthicum Shelly, M.S., R.N.
with Melanie Cowlishaw, M.S.N., R.N., and Judy Galloway, R.N.

Nurses are usually responsible for tube-feeding preterm neonates in the hospital. After discharge, the parents or primary caretaker are primarily responsible. In some developmental centers, infants who require tube-feeding may be fed by professionals or assistants from disciplines other than nursing. Appropriate training regarding tube feeding is necessary for the safety of the children involved.

Objectives and Goals for Nasogastric and Gastric Feedings

Be able to:

- Identify the equipment you will need to feed the child.
- Measure the length of the tubing needed to reach the stomach.
- Place the tube through the nose or mouth into the stomach.
- Check for tube placement in the stomach.
- Identify the formula to be used and measure the amount for one feeding.
- Demonstrate proper positioning of the child during the feeding.
- Feed the child through the tube without difficulty.
- Describe warning signals that could mean the tube has not been correctly placed in the stomach.

GENERAL INFORMATION

Use a nasogastric (NG) or oral gastric (OG) tube feeding when there is some physical or anatomical reason why a child cannot get enough calories by mouth to provide adequate nutrition. It may be for a short while or for an indefinite period of time. The tube may also be used to administer medications.

Oral gastric tube feedings are usually done in infants with severe cleft lip and/or palate because of their anatomy, or in neonates who are considered obligatory nose breathers, although they can be made to mouth-breathe by closing their nostrils. Howard and Winter et al. (1984) found that nasogastric tube feedings can usually be done in these infants past 3 or 4 months of age, after they are through the nose-breathing stage.

Some infants require tube feeding initially to maintain nutritional status.

INDICATIONS FOR NG OR OG TUBE FEEDINGS

- Refusal to eat (rule out behavior problems).
- Prematurity.
- Coma (short-term).
- Need for constant drip feeding, such as after severe diarrhea.
- Inability to suck.
- Severe neurological impairment.
- Cardiac problems.
- Chronic pulmonary disease.

PURPOSES

- To ensure proper and adequate nourishment when an alternative feeding method is impossible or contraindicated.
- To prevent aspiration and abdominal distention.
- To conserve calories, which may be important for a preterm infant.
- To instill feedings and medications safely and efficiently.

EQUIPMENT NEEDED

Feeding tube
Water
Large syringe
Pacifier (if appropriate)
Formula
Measuring container
Adhesive tape

PREPARING TO FEED THE CHILD

- Wash your hands.
- Pour correct amount of formula into measuring container. Place container in pan of warm water.

- Allow formula to reach room temperature. *Never* feed the child cold formula.
- Change the baby's diaper, if necessary. Wash hands again.

Restrain the child comfortably with head and shoulders elevated at a 30 degree angle and with the child lying on the right side. This promotes more efficient emptying of the infant's stomach. For optimal interaction during feeding, the caregiver should hold the child.

Prepare four pieces of adhesive tape: *(Adjust measurements for preterm babies.)*
- 1" piece to go around the tube when measuring the length.
- 6" piece to place above the child's lip and under the nose.
- 8" piece torn in half length-wise—use one piece to anchor the tube to the tape under the child's nose. Use the other piece to anchor the tube to the child's face.

TUBE INSERTION

1. Measure the length of tubing needed to reach the stomach: Hold the clear end of the tubing at the tip of the child's nose and extend it to the top of the ear. From the ear extend the tubing straight down to where it touches the end of the sternum (breastbone). With a small piece of tape, mark this spot on the tube.

   Proper insertion and anchoring of the tube is required before instillation to prevent aspiration of fluid into the trachea. Place both orifices in the tube below the gastroesophageal sphincter.

2. Wet the tip of the tube in the baby's mouth. Pass the clear end of the tubing through the child's mouth or nose. Continue to advance the tube with gentle force, doing it as quickly as possible. The quicker the insertion, the less uncomfortable it will be for the child. Stop when the area of tape on the tubing reaches the child's mouth or nose.

   If you meet resistance, it may be due to:
   - The child crying (which is normal).
   - The tube coiling in the mouth.
   - An obstruction.

   Never insert the tube after a feeding, whether it is a partial or complete feeding. The child could aspirate formula into the lungs if a tube is put down while there is food or formula in the stomach. Alternate sides of the nose each time the tube is put down, unless otherwise instructed.

It is normal for the child to gag, cough, cry, or become slightly dusky in color while the tube is being inserted. If the child seems unable to breathe or turns blue, remove the tube and let the baby rest a few moments before another attempt at insertion. The tube may also coil in the child's mouth. If it does, remove the tube, allow a rest period, and attempt insertion again. The child's crying may make passage of the tube slower and more difficult. If there is crying, push the tube down while the child is taking in air.

3. To prevent the tube from slipping out, take another piece of adhesive tape and tape the tubing to the child's face, close to the nose and mouth.

4. To check for tube placement in the stomach, attach the syringe to the end of the tubing and gently pull back on the plunger to the point of resistance. If you aspirate half or more of the total feeding, do not feed more.

5. If you aspirate more than 15cc of residual, subtract that amount from the current feeding. (If you want to give the child 160cc of formula and you aspirate back 30cc of fluid from the stomach, subtract 30cc from 160cc and give the child 130cc of formula.) Before feeding the child, always return any fluid removed from the stomach by slowly pushing down on the plunger of the syringe, except if the aspirate contains evidence of blood and excessive mucous. If the stomach contents are bloody, coffee-colored, black, or bile-tinged, remove the tube and notify the doctor.

   It is necessary to check the residual before each feeding to determine if all the previous formula has been absorbed. Maintain adequate fluid and electrolyte levels by refeeding the aspirate.

6. To be absolutely sure that the tube is in the baby's stomach and not in the lungs, disconnect the syringe and put the end of the tubing into a cup of water that is placed lower than the baby. If the water bubbles off and on with breathing, the tube is in the lungs and should be removed.

PROBLEMS FROM IMPROPER TUBE PLACEMENT

If the tube is not down far enough but is instead in some part of the esophagus, formula may be refluxed back up, and persistent aspiration of formula into the lungs can occur.

If the tube is down too far, such as at the base of the stomach or into the upper part of the small intestine, formula will not be in the stomach for a sufficient amount of time to be digested. Diarrhea or infrequent stools associated with feeding can occur. This may result in decreased absorption of calories so the child's weight does not increase. If abnormal abdominal distention continues to occur during or after feeding, especially if it involves cramping or discomfort, stop feeding the child and contact the doctor.

HOW TO FEED

1. When you are sure that the tube is in the child's stomach, remove the plunger from the syringe and attach the syringe to the tubing.

2. Pour the correct amount of formula into the syringe and let it flow in by gravity from a position usually 3"-5" higher than the level of the stomach. Do not push it in with the plunger, because the child could vomit. Add more formula as the syringe empties, to prevent air from getting into the tubing.

3. Observe the child for tolerance throughout the entire feeding. If the child gags or becomes restless, lower the syringe, pinch the tube, and allow for rest. If the child spits up, vomits, or changes color, pinch the tube and pull it out. Discontinue the present feeding.

4. If the child is crying or restless, the stomach musculature may contract, which can stop the fluid flow. In this instance, the child will need to be soothed and cuddled.

5. Eating is normally a social time, so try to hold the child during this time, if you can. Talking, touching, patting, and singing may all be beneficial to the child. However, if the infant appears overstimulated (which may be indicated by frowning, flailing, or gaze aversion), quiet swaddling may be more appropriate.

6. When the child has received all of the formula, pour 5cc of clear water into the syringe to clear the tubing. To remove the tube, pinch it off and withdraw it at a steady, moderate pace to prevent entry of fluid into the trachea during withdrawal. This pace helps avoid vomiting and/or trauma.

7. If the child has a history of reflux or vomiting after a feeding, wait 30 minutes to one hour before removing the tube.

8. Burp the child after the feeding, if appropriate. You may want to hold or cuddle the child after the feeding. If that is not possible, keep the child on the right side or in the prone position for at least 30 minutes.

CARE OF SUPPLIES

Wash the measuring container, syringe, and feeding tube with hot, soapy water after each use. Rinse well and dry.

Leave the plunger out of the syringe to dry thoroughly. Place the items on a tray that is covered with a paper towel.

Put another paper towel over everything on the tray. Store in a cool, dry place such as a cupboard.

CHANGING FEEDING TUBE AND SYRINGE

The tube can be left in place for three days. After three days, the tube starts getting clogged and broken down from gastric juices.

Most tubes can be reused, but after about a week to 10 days use a new tube. Newer polyurethane tubes can be indwelling up to a month. They can be weighted to help keep the tip in the correct location.

Continue to use the same syringe until it becomes difficult to use or until you cannot see the markings easily.

ADMINISTRATION OF MEDICATIONS

Give medications ½ hour before feedings or 1 hour after feedings. Do not give medications at the same time as a feeding (unless otherwise specified by the doctor) because this increases the potential for vomiting and/or decreased absorption of the medications.

- Wash your hands.
- Insert the tube if you give a medication before a feeding, or check for tube placement if you give it after a feeding.
- Draw up the medicine in an appropriate-sized syringe or medicine cup.
- Remove the plunger from a larger syringe and attach the syringe to the feeding tube. Add medicine to the syringe and allow it to flow by gravity.
- Flush the tube with 5-10cc of water to clear the medicine from the tube.
- Remove the syringe. Clamp or remove the tube.

MOUTH CARE

Daily mouth care is necessary. Use lemon-glycerine wash or lukewarm water on a gauze square or Q-tip to wipe out the child's mouth.

Give the child a pacifier to suck on, especially while being fed, to associate feeling full from formula with sucking. For as yet unknown reasons, sucking may also facilitate weight gain.

FEEDING TUBES FOR PRETERM INFANTS

Most preterm or LBW infants are fed with number 5 French feeding tubes. Another tube that has been used extensively at the University College Hospital in London is a very, very fine feeding tube. It is cut from a reel of Portex pp50 tubing. The staff at this hospital have found several advantages in using this type of tube:

- It does not block the infant's airway.
- It can be left in for 48 hours.

- It does not fall out as easily as a wider tube, because it is extremely lightweight.
- The formula drips in slowly, which is desirable, even if it is pushed in with a syringe.
- It can be used with a continuous feeding pump.

Some of these principles also apply to the number 5 French feeding tube. It is wise to use a very fine feeding tube if an inexperienced caregiver is feeding a baby too fast. Another reason is that a fine tube blocks the baby's nostril less. The diameter of the pp50 tube is so small that a needle must be attached to the end of it before the syringe can be put on. Research on the effectiveness of these fine tubes over standard feeding tubes has not been located from any facility other than the hospital in London.

Common Tube Feeding Problems

PROBLEMS	POSSIBLE CAUSES	POSSIBLE SOLUTIONS
Diarrhea	Too rapid feeding	Slow feeding
	Too concentrated formula	Dilute with water or Pedialyte (consult with doctor or nutritionist)
	Intolerance to formula	Formula change
	Medications	
	Malabsorption	
	Bacterial overgrowth	
Cramping	Cold formula	Room temperature formula
	Tube in wrong place	Reposition
	Too fast feeding	Slow feeding
Constipation	Inadequate fluid	Use more water to rinse and with medicine
	Lack of fluid in diet	Increase fluids or prune juice *(consult physician first)*
	Lack of activity	
Vomiting	Too rapid feedings	Slow feeding
	Tube too large	Use smaller sized tube
	Improper tube placement	Reposition
	Large residual in stomach	
	Formula too concentrated	
	Medications given with feedings	
Nausea	During feeding may indicate delayed gastric emptying	Stop feeding: resume when nausea stops
	Stomach distention	
	Too cold formula	
Reflux	Large residual in stomach	Elevate head before, during, and 30 minutes after feeding, or as suggested by results of a pH probe evaluation for reflux. Place the child in prone position.
	Physiologic problem	Thicken feedings (add baby rice cereal to feeds)
		Use a reflux harness
		Medications prescribed by doctor

Objectives and Goals for Gastrostomy Feedings

Be able to:

- Identify the equipment needed to feed and care for a child with a gastrostomy.
- Identify the formula to be used and measure out the amount needed for one feeding.
- Demonstrate proper positioning of the child during feeding.
- Feed the child through the tube without difficulty.
- Describe what to do if the tube comes out.
- Describe how to care for the skin around the gastrostomy tube.
- Describe signs of possible infection of the skin around the tube.

GENERAL INFORMATION

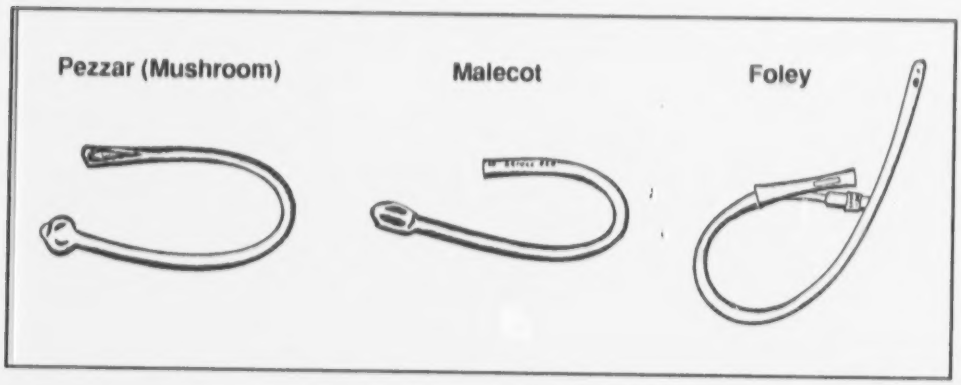
Howard and Winter (1984) described how to place a gastrostomy feeding tube through the abdominal wall into the stomach and anchor it with a purse-string suture during surgery. Use this tube when tube feedings are required for an extended period of time.

The most common types of tubes are:

- Pezzar or mushroom catheter
- Malecot catheter
- Foley catheter

Huddleston et al. (1989) found that Foley catheters were considerably cheaper than the others, were less likely to be dislodged, and had fewer problems with skin care and tissue overgrowth.

Currently, gastrostomy buttons are frequently being used. The buttons have a closure on the skin surface that resembles the closure on dishwashing soap lids. This way the closure can be opened and closed, and it lies close to the skin rather than having a long tube protruding from the abdomen.



INDICATIONS FOR GASTROSTOMY TUBE-FEEDINGS

- Inability to suck or swallow.
- Coma (long-term).
- Some congenital anomalies such as esophageal atresia, tracheal-esophageal fistula, or some types of cleft palate.
- Esophageal injury with obstruction such as can be caused by the ingestion of caustic chemicals.
- Home tube-feeding when the parents cannot manage a nasogastric tube.

PURPOSES

- To promote absorption of fluids through the stomach by avoiding esophageal reflux and vomiting/aspiration.
- To promote adequate nutrients and fluid and electrolyte balance.
- To promote weight gain.

EQUIPMENT NEEDED

Formula
Measuring container
Water
Large syringe

PREPARING TO FEED THE CHILD

- Wash your hands.
- Pour the correct amount of formula into a measuring container. Place the container in a pan of warm water.
- Allow the feeding to reach room temperature.
- Change the baby's diaper, if necessary. Wash your hands again.
- Place the child on the right side with head and shoulders elevated at a 30 degree angle. This helps prevent reflux of fluids.
- For optimal interaction during feeding, hold the child.

HOW TO FEED

- Check for proper placement of the tube. Pull out the tube so you can feel under the skin the balloon (or bulge) that holds it in place. The Helping Hand-Homegoing Program suggests placing a piece of tape around the tube where it enters the abdomen. Attach a nipple around the tube so the tube does not slip further into the stomach between feedings. Measure the length of the tube frequently to make sure normal digestion is not pulling the tube further into the stomach.
- Offer a pacifier to the infant if appropriate. Using a pacifier helps the infant associate oral gratification with hunger.
- Unclamp the tube and insert the syringe with the plunger in. Then pull it back gently.

- If the aspirate is more than 15cc, subtract this amount from the total feeding. Refeed the residual if appropriate by slowly pushing down the plunger of the syringe.
- Temporarily pinch the tubing with your fingers while disconnecting the syringe. Remove the plunger from inside the syringe and reconnect the syringe to the end of the tube. Now release the tubing from your fingers.
- Pour the correct amount of formula into the syringe and let it flow in by gravity. Do not push it in with the plunger. Add more formula as the syringe empties to prevent air from getting into the tubing. Regulate the rate of the feeding by noting the speed with which the syringe is emptying. The height of the feeding apparatus above the infant's stomach determines the rate of flow. Clamping or pinching the tube will prevent fluid from entering the stomach rapidly. The length of the feeding time should be equivalent to the time required for oral feedings.
- Flush the tube with 5cc of water at the completion of the feeding. This ensures patency of the tube and delivery of the entire feeding.
- If there is any sign of discomfort, stop the feeding by lowering or clamping the tube. The baby may need to burp, or the feeding may have stimulated a bowel movement (any straining will force the feeding back up into the syringe). You may even find that the child will pass gas through the tube.
- When the feeding is completed, clamp the tube. Leave the syringe attached without the plunger in it if the gastric tube is to remain open. An open gastrostomy tube will prevent reflux and abdominal distention.
- Burp the baby after feeding if appropriate. You should hold and cuddle the child after the feeding. If you are not able to hold the child at this time, position the baby on the right side for at least 30 minutes.

CARE OF SUPPLIES

- Wash the syringe and the measuring container with hot, soapy water after each use.
- Place a paper towel on a tray and place the items on the tray.
- Cover with another paper towel.
- Place in a cool, dry place.

TO PREVENT LEAKAGE FROM THE TUBE AND IRRITATION TO THE GASTROSTOMY SITE:

Equipment and materials needed:

Gauze (4x4s)
Paper tape—1" wide
Scissors with a point
Adhesive tape—½" wide
Baby bottle nipple

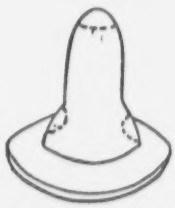
Preparing the materials:

- Wash your hands.
- Cut four pieces of paper tape 3"-5" long.
- Cut one piece of adhesive tape 2" long.

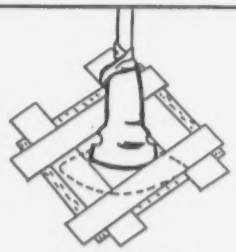
- Stab a hole with the point of the scissors in the end of a baby bottle nipple large enough to slip the gastrostomy tube through. Cut a smaller hole on each side of the nipple. This allows air to circulate. Use the nipple until it starts to get soft and sticky.

Securing the tube to the nipple:

- Fold two pieces of gauze in half and place over the gastrostomy site around the tube.
- Remove the clamp from the tube. Slip the nipple over the tubing until it touches the gauze.
- Pinch the tubing and clamp.
- Tape the nipple to the gauze and to the skin with paper tape on all sides.
- Tape the gastrostomy tube at the top of the nipple with adhesive tape to keep the tube's bulb pulled up against the opening in the stomach.



Remove the portions of the nipple indicated by the dotted line.



Secure the nipple around the gastrostomy tube.

The concept of securing the tube through the nipple is from the Helping Hand-Homegoing Education and Literature Program.

CARE OF SKIN AROUND THE GASTROSTOMY TUBE

Equipment and materials needed:

Mild soap
Washcloth
Water
Karaya paste (optional)

Procedure:

- Remove the nipple and wash the skin around the tube every day.
- Use a washcloth or your hand and soap and water to gently wash the skin around the tube. You can do this during bath time.
- After the child's skin is dry, put a clean gauze around the tube.
- Tape the nipple over the gauze.
- Keep the skin clean and the gauze dry to prevent the skin from becoming red and irritated.

If the skin around the tube gets red or formula starts to leak around the tube, stop using the gauze. Instead, apply a small ring of Karaya paste over the skin around the tube. Let the paste dry to a dull finish (several minutes) and apply the nipple over it. You may also apply an over-the-counter antacid product.

Do not try to scrub off the Karaya paste while bathing the child. That will irritate the skin more. If the skin remains red after using the Karaya paste, notify the child's doctor.

GASTROSTOMY TUBE REPLACEMENT

Always keep an indwelling Foley catheter on hand in case the gastrostomy tube comes out. It is important to insert another tube when the gastrostomy tube comes out, or the ostomy site will begin to close. If the tube has been out for only a short period of time, the new tube should slide through easily. If it has been several hours, you may find the abdominal muscles have closed tightly and the catheter will bend rather than go in.

- Check to see whether the balloon on the new tube is intact by inflating it with several cc's of water in the small part of the "Y." Then deflate it.
- Insert the catheter into the ostomy opening approximately 1 inch beyond the balloon. With a small syringe, insert 3-10 cc's of water into the balloon through the small part of the "Y." The amount of water to be inserted is indicated on the catheter. Pull back on the tube gently until you feel the balloon tighten against the abdominal wall.
- Anchor the tube with the nipple as described earlier and clamp the tube. Call the child's doctor.

If you feel uncomfortable placing the new tube, cover the ostomy site with a cloth diaper and call the child's doctor. The tube should be replaced before the next feeding (within 4-6 hours).

COMPLICATIONS

Reinsertion
Intraperitoneal leaks
Stomal leak/stomal enlargement
Infection
Tube prolapse (sucks into the stomach)
Non-closure of the stoma

Most tubes have to be changed or replaced only twice a year.

Potential Problems

WHEN YOU SEE	THEN
An increase in redness	Apply an over-the-counter preparation such as bacitracin and/or cortisone cream ointment. Also, an over-the-counter antacid (Amphogel, Maalox) is excellent to put around the stoma site. If the

	redness continues to extend or there is foul-smelling, thick drainage or pus, call the doctor.
The tube being mildly pulled in by tugging of the stomach (peristalsis)	Pull the tube out to its proper position and secure by wrapping the tube with a piece of tape or by securing the tube around a nipple.
The tube cannot be pulled back to the markings and there may be cramps, discomfort, or some other problem	The tube has probably worked its way into the small intestine. Call the doctor; surgery may be necessary.
Hissing or flow of liquid around the tube	Hissing usually indicates a buildup of gas. Unclamp the tube and hold it up to prevent loss of liquid. This allows the gas to escape. Constipation also creates pressure and can force back the feeding around the tube.
A continuous flow of feeding around the tube	Check the position of the tube so that it does not pull tightly against the skin, creating an opening on the opposite side. This frequently happens if the tube is pulled down tightly, with the tube acting almost like a wick. Reposition the child—either by elevating the head or turning onto the right side.
Clogging with medicines or other liquids	Gently push several cc's of water into the tube, then pull back. Repeat. Remember always to follow a feeding or medication with water to clear the tube. When all else fails, change the tube.

Definition of Terms

Aspirate: Material obtained from the stomach by pulling back on the feeding syringe.

Aspiration of Fluid: Material that goes into the lungs from the stomach during vomiting or reflux.

French Number: The designation of the size of the feeding tube—the smaller the number, the narrower the diameter of the tube.

Gastrostomy Tube: A feeding tube that goes into the child's stomach.

Gavage Feeding: Feeding through a tube passed into the stomach.

Nasogastric Feeding Tube: A tube that goes through the nose down to the stomach.

Oral Gastric Feeding Tube: A tube that goes through the mouth down to the stomach.

Residual: The amount of formula remaining in the stomach from a previous feeding at the time of the current feeding.

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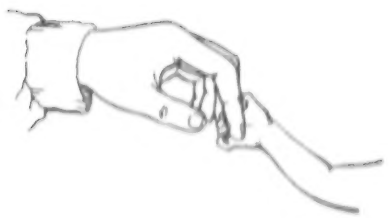


Developmental Assessment and Outcome

An Introduction to Measurement Concepts and Standardized Testing

by Nancy M. Bray, Ed.D.

The expanding number of programs for handicapped, developmentally delayed, and at-risk children represents the increasingly positive direction of the special education service delivery system in the United States. In order to place children properly in newly developed programs, there must be careful assessment to determine developmental status and to monitor progress. This attention increases the expectation for well-constructed testing instruments to assess various aspects of a child's physical and developmental status.

Assessment is a process that consists of the following elements:

- Identification of a child potentially in need of special services.
- Screening to assess the child's general physical and developmental status.
- Comprehensive assessment to determine strengths and areas of difficulty.
- Continuous or on-going assessment to monitor the child's progress.

The Purposes of Assessment

IDENTIFICATION

Determining those children who may be developmentally delayed or at risk for future problems requires a mechanism for identification. There are many opportunities for identification of potential problems, particularly within the health care system, and medical professionals have responded admirably to this need. For example, health professionals are acutely aware of the importance of providing optimal care during pregnancy for high-risk mothers; infants of these mothers may be at risk for developmental problems and must be carefully observed.

Some of the mother's risk factors that may affect her baby are

- Diseases such as diabetes.
- Conditions such as drug addiction.
- Age-related problems such as adolescent pregnancy.
- Previous problem pregnancies.

Often children of these mothers are carefully watched in order to monitor their progress. Other opportunities for identification occur during the first few days of life, when the neonate's condition is carefully observed to determine indications of potential difficulties. Very low birth weight infants are prime candidates for monitoring because of the higher incidence of developmental problems within this group. There are other children for whom no risk states have been identified, but who seem to develop in ways that appear outside the range of normal. This may be due to some disorder, such as cerebal palsy, or because of certain generalized or specific developmental delays. All of these children benefit from a screening evaluation.

SCREENING

When a child seems to be developing in a way that deviates from usual standards, screening is indicated. The process allows a relatively quick, economical evaluation of a child in several areas, including physical status, general development, vision, and hearing. Results of such a screening should indicate if a child is performing within expectations. If not, it will serve to identify a child who should be referred for comprehensive screening services.

One widely used screening instrument is the *Denver Developmental Screening Test (DDST)*, which has played a major role in early identification efforts in the United States. An adaptation of the DDST is the *Denver Pre-Screening Developmental Questionnaire*, which allows parents to respond to questions regarding their child's development. This helps flag those children in need of comprehensive screening. Many public health nurses and pediatricians in private practice routinely use developmental screening as a part of their well-child medical services. When using the DDST with children during the first 3 months adjusted age, it is extremely difficult to obtain a failing score.

COMPREHENSIVE ASSESSMENT

If a child's developmental status is questioned, a referral for an in-depth comprehensive assessment to validate the screening results is usually the next step in the process. Often professionals from a variety of disciplines conduct this portion of the testing in order to evaluate a child's physical, developmental, and psychosocial status. The examiner may have to determine if a child's apparent difficulties are caused by immaturity, by delay, or by an abnormality. The examiner also typically assesses the quality of the child's skills. Completion of the evaluation allows determination of a child's status relative to other same-age children. It also provides information useful in

determining if the child should be referred for an intervention program. Although the purpose of a comprehensive evaluation may be to determine program eligibility, the results may also suggest general areas for intervention. Often these screenings provide valuable information for research as well.

PROGRESS MONITORING

Ongoing assessment of the developmental status and progress of a child enrolled in an intervention program is vital. Most early childhood interventionists use assessment to determine the next developmental step and also to evaluate the extent of progress. Assessment and programming are inextricably linked. An assessment derived from observation of a child's daily or weekly progress in a program is usually more precise and reliable than a separate, outside evaluation. This is because the information accumulates in an ongoing fashion during the process of serving the child. Within a program there are opportunities to get to know the child in a familiar environment, to observe actual abilities and areas of difficulty, and to try out innovative strategies to facilitate the child's development.

All the stages within the assessment process are important. The underlying goal is to get those children who need intervention into an appropriate program, and to continue to monitor their developmental progress within that program.

Following is an overview of concepts related to assessment of young children. Specifically addressed are norm-referenced tests as they are used in comprehensive assessment efforts.

Using Tests for Comprehensive Assessment

Because of the importance of assessment, it is critical for those who conduct evaluations or who use this information to be knowledgeable about the different types of tests employed in the assessment of young children. They should also be aware of test construction methods, psychometric characteristics of tests, and factors in interpreting findings.

NORM-REFERENCED AND CRITERION-REFERENCED TESTS

Examiners use two types of tests to assess individuals: norm-referenced and criterion-referenced. They each have different purposes.

Norm-referenced tests evaluate a child using a standardized measure. This type of test compares a child's performance with that of a reference or normative group, usually children of similar chronological age, or within the same age

range, or with a similar characteristic such as mental retardation. Information gained through norm-referenced instruments typically is used for classification purposes to answer a question such as, "Does the child demonstrate significant difficulties that warrant intervention in a special program?" Results are presented using scores such as Developmental Indices, Standard Scores, Percentile Ranks, or Age Scores.

Criterion-referenced tests provide more detailed information about a child's functioning. Typically, this type of test describes a continuum of skills or behaviors in a specified area. The examiner offers the child numerous opportunities to respond to each of these developmental steps, using a variety of materials over a period of time. The focus of intervention is to manipulate the environment so the child will meet success in the next steps. For example, when a child is using single words, providing opportunities to expand language to the use of two-word sentences is a typical strategy. Obviously, some developmental areas are easier to program for than others. Criterion-referenced instruments rarely provide normative data determination of what level a child is functioning on other than that estimated within a broad or general range. The value of this type of assessment is that it specifies the nature of the intervention that is appropriate. This type of assessment is costly in terms of financial and time requirements and is done for a different purpose than norm-referenced tests.

STANDARDIZED TESTS

The term *standardized test* refers to a norm-referenced instrument that has strict, uniform procedures for administration and scoring. These procedures have been carefully specified by the test developer. Following the designated stringent procedures is of vital importance because it ensures comparison of a child's abilities or skills with the normative group. If an examiner arbitrarily modifies procedures in ways not specified by the test developer, the results are invalid. Only by adhering to those conditions established during the test development phase are users able to compare the data in meaningful ways.

Examiners interested in intervention receive rather limited information about a child from standardized tests. One reason is that this type of assessment is often completed within a single session in an environment unfamiliar to the child. Under these circumstances, the examiner must be exceedingly cautious not to over-interpret results. In addition to test results, the examiner needs other corroborating evidence about a child's developmental level from a parent or caregiver who knows the child well. In general, standardized norm-referenced tests do not reflect *all* that the child knows or can do. Thus their value is limited.

Clinicians who use standardized instruments need to be aware of test construction methods in order to understand the results. In the beginning stages, the test developer accumulates a pool of potential test items from a

variety of sources, including other published instruments, conventional wisdom, and theoretical constructs. The test developer then administers this pool of items to a group of children across the targeted age span. Administration to the standardization group follows a predetermined administrative and scoring protocol. The tester carefully selects the normative group to provide adequate representation of certain characteristics. These include sex, ethnicity, socioeconomic status, parental characteristics, place of residence, and other important parameters. Using such a stratified random sample allows comparability of one child's performance with that of a group of other children from a similar background. During the process of test development, tasks may turn out to be too easy (passed by a majority of children), or too difficult (passed by very few children), or of little value for some other reason. The goal is to select those items that will discriminate achievers from nonachievers at a certain level. Test developers frequently use the criterion of the 50% level; they select only those items that half the norm group answers correctly and half gets wrong. This is a generally standard procedure in determining which items to include in norm-referenced or standardized instruments. Many tests also provide information relating to the

Adequate infant assessment requires an understanding of test and measurement principles.

age range for the attainment of certain skills, thus underscoring the normal variability of populations. It is important for professionals using standardized instruments to understand that most tests are not designed to assess *all* important areas, but instead evaluate *samples* of a child's behavior, using a restricted pool of items. Thus, because of the procedures followed in the development of standardized instruments, administration of a test does not ensure a total picture of a child.

In the selection of assessment instruments, it is very important for the examiner to evaluate the standardization sample of the test being considered, relative to the child or the particular group of children who will be assessed. For example, a test standardized with a group of middle-class American children may be inappropriate when used with a child from a lower socioeconomic background or one who is from another country. The sample size is also important; tests that have based their scores on results with only a

few subjects may be questionable. The test manual provides information about the characteristics of the standardization group, and it is incumbent upon the examiner to ensure that the instrument selected for a child is appropriate.

As part of the standardization process, test developers complete studies to document the technical characteristics of the instrument, including determination of the validity and reliability of the test. The *validity* of a test refers to how well it measures what it is supposed to measure, such as how well results from the testing separate those children who may have a developmental delay in a given area from those who do not. Validity studies often use comparisons of performance on a given test with results on a criterion-measure, a test that is considered to be a standard in the field. The *reliability* of a test refers to its accuracy or precision in yielding consistent results. One means of estimating reliability is determining if a test produces the same scores when re-administered using the prescribed procedures.

The user's manual for a particular test should provide detailed information regarding its technical characteristics. This information also exists in reviews or studies in professional journals. Another important source is the *Mental Measurements Yearbook* (MMY) edited by O. K. Buros, which is a standard reference book available in most libraries. The MMY offers comprehensive analysis of many standardized tests, notation of studies that have been completed regarding the tests, and critical reviews by assessment professionals. There are many other texts that provide comprehensive coverage of the construction, development, and evaluation of tests. Because a test is published, well known, or frequently used does not necessarily mean it meets the desired standards for use.

Some Commonly Used Tests

The use of norm-referenced tests with potentially delayed young children remains important in accessing services. There are many commercially available tests that are used regularly in determining whether a child is eligible for an intervention program.

BAYLEY SCALES OF INFANT DEVELOPMENT

The Bayley Scales of Infant Development (Bayley, 1969) is one of the most frequently used instruments to assess children up to 30 months of age. There are three components to this test: the Mental Scale, the Motor Scale, and the Infant Behavior Record. Tasks within the Mental Scale assess such functions as memory, learning, perception, problem solving, and early verbal communication; tasks within the Motor Scale evaluate a child's gross motor and fine motor abilities. After both scales are completed, the Infant Behavior Record allows rating of the child's reactions observed during the assessment

period. This includes perceptions of the child's emotional and social behavior, attention span, persistence, and goal-directedness. The Mental and Motor Scales provide developmental indices that have a mean of 100 and a standard deviation of 16. The Bayley Scales may be appropriate for determining a young child's current developmental status, but caution must be used in predicting future abilities from the results.

STANFORD-BINET INTELLIGENCE SCALE

Another commonly used standardized measure is the Stanford-Binet Intelligence Scale, which is used with children as young as 2 years of age. The test is arranged by half-year levels beginning at age 2 and continuing to age 5. After 5 years, the tests progress by year levels. Within each of these levels are six subtests that differ from age to age. At preschool age levels, the examiner presents a variety of tasks. These include fine-motor, perceptual, and language items. The Stanford-Binet uses a basal-ceiling format in which the tester administers only those items that span the child's ability level. Scores are presented in deviation intelligence quotients with a mean of 100 and a standard deviation of 16, and a mental age.

McCARTHY SCALES OF CHILDREN'S ABILITIES

The McCarthy Scales of Children's Abilities have gained recognition in recent years as a means for evaluating children who are between the ages of 2½ and 8½. The test has 18 subtests that are grouped within five scales: Verbal, Perceptual-Performance, Quantitative, Memory, and Motor. Subtest performance within each of these realms is indexed by scaled scores with a mean of 50 and a standard deviation of 10. In addition to scores on these individual scales, a General Cognitive Index can also be computed from the composite of the Verbal, Perceptual-Performance, and Quantitative scales; this global score has a mean of 100 and a standard deviation of 16.

VINELAND ADAPTIVE BEHAVIOR SCALE

Adaptive behavior is another area that examiners often assess when determining the developmental functioning of young children. The assessment of adaptive behaviors allows evaluation of a child's performance in daily activities from the parent's or caregiver's perspective. The Vineland Adaptive Behavior Scale is one such standardized measure. Using an interview format, a person familiar with the child responds to open-ended questions about the typical behavior of the child at home and in the community. Test items cover four primary areas: Communication, Daily Living Skills, Socialization, and Motor Skills. In addition, the Vineland also includes a supplemental scale to evaluate the maladaptive behavior domain. The standard scores have a mean of 100 and a standard deviation of 15. Also provided are percentile ranks, stanines, adaptive levels, and age equivalents.

BRIGANCE DIAGNOSTIC INVENTORY OF EARLY DEVELOPMENT

After a child is enrolled in a program, monitoring efforts often include the use of criterion-referenced measures. One such instrument is the Brigance Diagnostic Inventory of Early Development. The Brigance contains approximately 100 skill sequences, which evaluate developmental sequences in children from the developmental levels of birth through 6 years. Skill sequences are included within the following realms: psychomotor, self-help, speech and language, general knowledge and comprehension, and early academic skills.

Other Factors

The focus of this article is the use of standardized tests for classifying young children. However, examiners typically design intervention programs based on information gained from other assessment procedures instead of the tests. For example, Fewell (1983) emphasized the importance of evaluating such factors as dyadic exhanges and social behaviors, states of arousal, habit patterns, temperament, reactivity to perceptual-cognitive events, play behavior, and attention. Standardized tests do not assess these areas.

Interpreting Test Scores

Test scores tend to be distributed around "average" in a characteristic way. More children earn test scores that are considered normal than do those who earn scores that are very low or very high. Much of measurement theory is based on the assumption that within the overall population, an individual's abilities tend to be distributed in ways that conform with the theoretical normal curve.

To use a practical example, consider the size of infants at birth. Most of the newborns delivered in the United States weigh within the average range, somewhere around 2900 to 3800 grams. A few infants would be very small and a few would be very large. This can be described through the use of central tendency and measures of dispersion.

Measures of central tendency are the *mean* (also called the arithmetic average), the *median* (the midpoint in a distribution, or that point above and below which 50 percent of the scores will fall), and the *mode* (the most commonly or frequently occurring score). In a *normal distribution*, the mean, median, and mode will all be at the same point. Subgroups within the overall sample—for example, infants of low socioeconomic status mothers—may have a different

may be useful when comparing a child's characteristics with that of a certain subgroup or with an overall sample. Often an examiner is interested in comparing a given child's characteristics with those that might be typical of the mean for that child's age or with the median of a specific group.

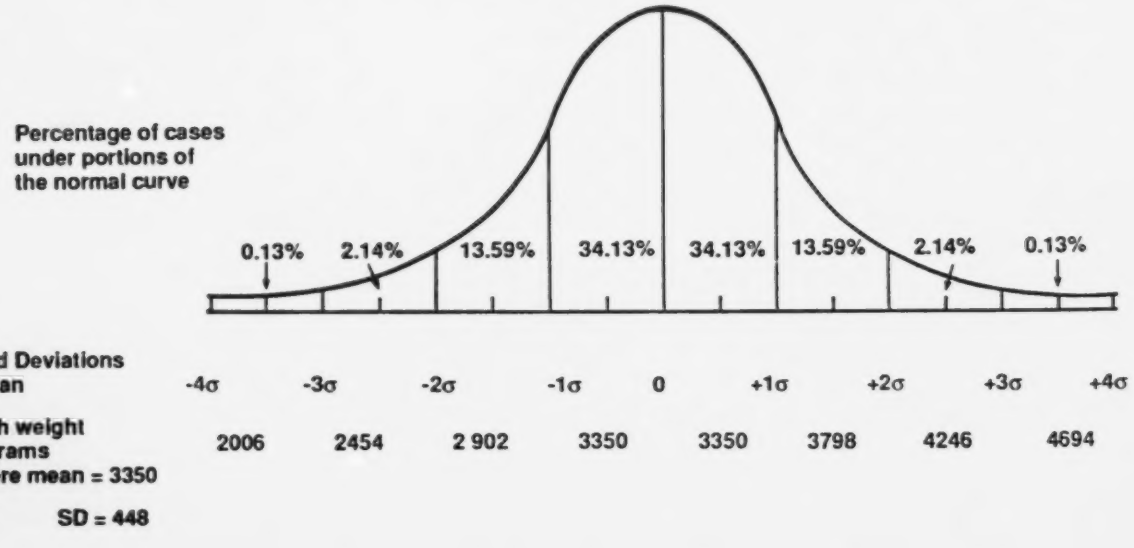
The examiner may also be interested in determining a given child's characteristics relative to measures of dispersion. This may be done either by using the *range*, such as "most babies weigh from 2900 to 3800 grams," or by using the *standard deviation*, a term that refers to a means of marking off the normal curve into equal intervals. The following diagram of a normal curve illustrates this. It demonstrates the percentage of cases that would fall within each interval. (Figure 1)

The standard deviation is designated by the Greek symbol sigma (σ). Six standard deviations cover the majority of cases, ranging from a plus three to a minus three standard deviation units. Approximately 68% of the cases would be expected to fall between plus and minus one standard deviation unit based on the theoretical normal curve. Using the previous example, if the mean or average birth weight is 3350 grams and the standard deviation is 448 grams, then 68% of the infants would weigh between 2902 and 3798 grams. This would be considered the average range or "within normal limits." Children whose birth weights are outside this band would be considered discrepant from the norm.

The normal curve provides a reference point for interpreting information such as height and weight or test scores. Several types of test scores are based on the normal curve, including standard scores and percentile ranks.

A *standard score* is a derived score that is one of the most useful indexes of a child's performance. A standard score provides a numerical basis for

Figure 1



describing how far a child's score deviates from the mean, relative to the normative group. Developmental Quotients or Intelligence Quotients are usually standard scores. Commonly, the test developer predetermines the average of a given test to be 100, and sets the standard deviation at 15. Using this basis, the *average range* would include those scores that range between plus and minus one standard deviation, or between 85 and 115.

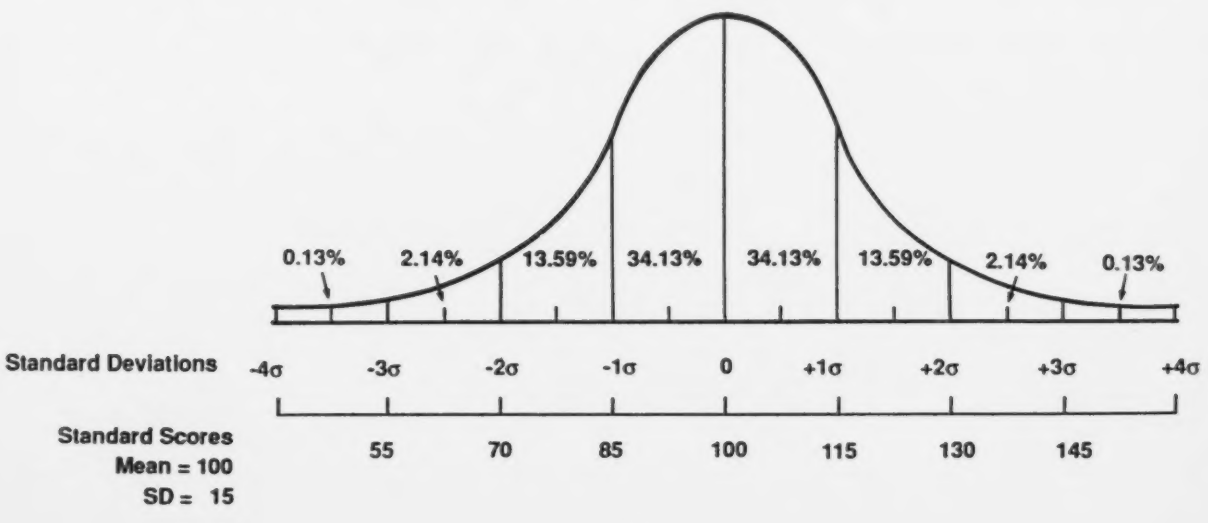
Consider an example. From results of testing, it is determined that a child's performance yielded a standard score of 62 (where the test average is 100 and the standard deviation is 15). As can be seen on Figure 2, this score is more than two standard deviations below the mean. By most standards, this child demonstrated development within the delayed range in whatever behaviors were being assessed at the time of testing.

When using the normal curve as a basis for test score interpretation, Figure 3 illustrates the descriptions that professionals from many disciplines employ.

Some professionals interpret test findings in a more generous fashion than shown in Figure 3. A child earning a Developmental Quotient (standard score) that is less than two standard deviation units below the mean—a score above 70—would be considered within the average range; a child with a lower score—a score below 70—would be considered significantly delayed. Test developers often provide their own unique classification or interpretation guidelines for test scores, which they describe in their test manuals. It is important for the user of this information to clarify *whose* standards are being used to describe a child's functioning level.

Many professionals prefer to use *percentile ranks* when describing a child's performance. A percentile scale ranges from 1 to 99, with 50 as the average. Figure 4 shows percentile ranks and their relative position on a normal curve.

Figure 2

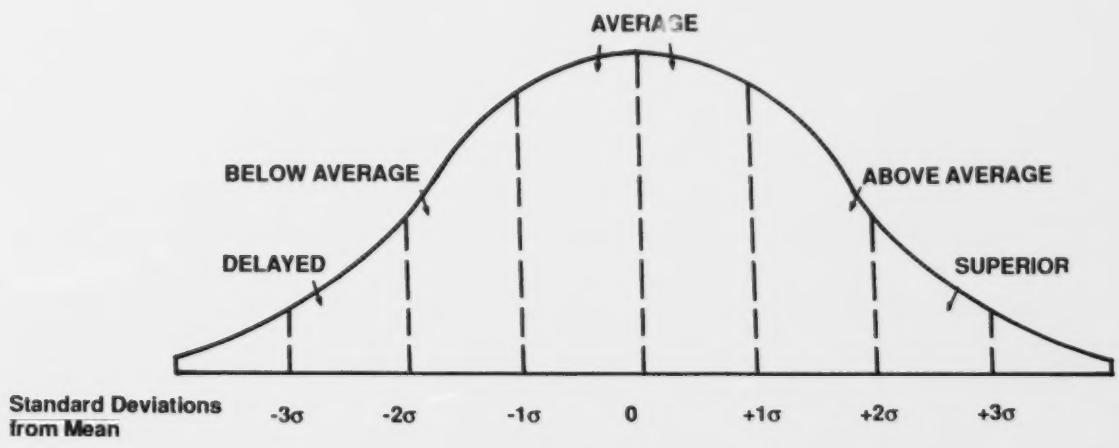


The percentile rank means scoring equal to or better than a certain percent of the normative group. If an examiner determines that a child's performance on a test results in a percentile rank of 42, this means that the child's performance is equal to or better than 42 percent of the children in the normative group. Another way of presenting the same information is to say that this child's performance is excelled by 57 percent of the children taking the test. It is important for professionals using this scale to be knowledgeable about the relationship of the percentile scores to the normal curve, and where certain scores are placed relative to the standard deviation units. For example, note the variability in percentiles across the normal curve. There is a dramatic difference between the 1st and 10th percentiles that far exceeds the difference between the 40th and 50th percentiles.

It is not uncommon for a child's performance at the 35th percentile to be described as an area of delay or weakness, and a performance at the 60th percentile is often described as a strength. Yet, when one examines the normal curve, it is apparent that the average range, plus and minus one standard deviation unit from the mean, includes percentile ranks between 16 and 84. Thus a score at the 35th percentile is clearly within the average range by most standards. Scores greater than the 84th percentile might be considered strengths. Scores below the 2nd percentile are those that are significantly delayed. When an examiner provides percentile rank data without explanation to parents, it is often misunderstood and misinterpreted. Professionals may find it helpful, when they are interpreting test scores, to provide the parents with a copy of the normal curve, and to discuss the rationale of the normal curve. It may also be helpful to discuss what is considered the average range, and to chart the child's score(s).

It seems more the rule than the exception that examiners interpret test scores for young children using Age Equivalents. In many respects, this type of score

Figure 3

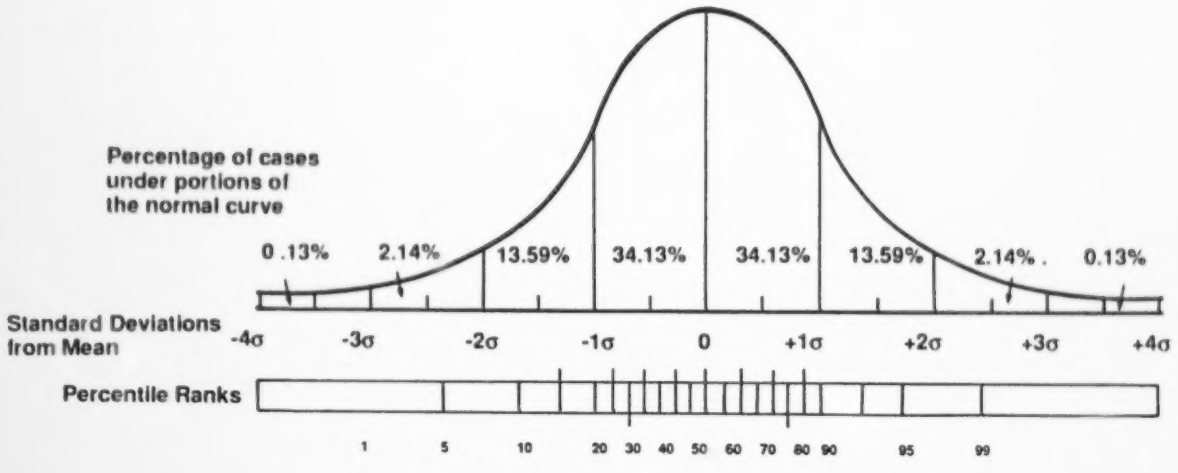


is misleading because it does not indicate the expected spread of scores within any age level. An *age equivalent* score is based on the median scores earned during the standardization of a test; it indicates the age level at which the middle-ranking child earned that raw score at that time. For illustration, assume that on a test being standardized with a group of young children, the raw scores (the actual number of test items correct) ranged from a high of 32 items correct to a low of 8 items correct. In order to assign an age equivalent, the test developer arranges the scores from high to low and then targets the median score, or the midpoint; this score is assigned to be a particular age equivalent. Interpretation is that a given child's raw score is the same on this developmental test as the median score made by other same-age children from the standardization sample. It would be misleading to report that the child "is functioning at the 8-month level." It would be correct to report that the child's number of successes are the same as that obtained by the middle-ranking 8-month-old in the standardization sample. Related to this interpretive issue is the typical situation in which the child's performance on a test is scattered across an age range, such as from 6 to 11 months. That child is not functioning at one specific age level, despite earning a specific score on the test. The examiner must be cautious in reporting results to ensure accuracy.

Projecting Beyond Test Scores

Most parents question the predictability of scores obtained during developmental testing of a young child. A number of studies have evaluated the stability across time from scores obtained during the early childhood years to subsequent performance in school-age and adult years. The literature generally reveals that the results of tests administered to children under the age of 2 years are not good predictors of subsequent intellectual testing, at

Figure 4



least with normal children. Studies using handicapped children show better stability. The most severely handicapped children early in life tend to obtain lower scores later in life; thus, stability is quite good. Be cautious in interpreting results to parents based on these conclusions. Generalizations from groups of children may not be applicable to an individual child.

Parents often ask, "How will my child function in the future?" If professionals knew the answer to that question, decision making would be easier. Early intervention researchers have devoted considerable attention to predicting the future, and professionals are very interested in developmental outcomes for children with specific types of difficulties. However, those who work with young children must understand that they may not always be able to generalize the results of research to a specific child. In addition, there is the known variability within what is considered the normal range. For example, there are children who are late bloomers who may end up not very different from most people. Therefore, professionals must exercise great caution in presenting information about test results to parents.

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Cognitive and Language Development

by Allan K. Bird, Ph.D.

Since the early 1950s, researchers have studied extensively the developmental problems of children born at risk. Because of the advances in medical technology, many low birth weight (LBW) and very low birth weight (VLBW) infants who would previously have died are being maintained. Along with a dramatic decrease in the mortality rate, there has been increased concern about developmental outcomes. Intelligence, or cognition, is an area of study that warrants further concern. Intelligence is a significant indicator of the ability of a child to make adequate adjustments throughout life to the environment in which the child is placed. The area of language is a subset of cognitive skills. This chapter looks at the development of cognition and language, describing the long- and short-term consequences of being born at risk for the LBW child; it also reviews intervention strategies that might be appropriate.

Views of Cognition

Many of the beliefs about cognitive development have changed since the late 1960s. Older views held that infant cognition is a stable, unchanging, inherited capacity that is little affected by teaching or training. Lewis (1973) stated that infant intelligence was conceived as a "finite potential with which an individual was endowed at conception, the manifestation of which is increased at a stable rate during the growth process, but which was subject to neither qualitative changes nor to environmental influence."

Current beliefs about infant intelligence argue that cognitive performance consists of relatively discrete abilities or traits, with qualitative shifts in the importance of these factors at various levels of development and different times in a child's life. For example, while cognitive development must include the use of verbal skills, the timing of acquiring them varies. During the second to fourth year of life, acquisition of language may be the major skill learned.

While language continues to develop in a child after the age of 4, the rate of acquisition of this skill is less dramatic as the child grows older.

Problems in Study Comparisons

The nomenclature and definition of terms associated with the LBW child present major methodological problems in interpreting the literature. Even the most superficial review reveals terminology that is not consistently applied from one article to another. Authors have used various criteria to define the preterm infant. Some of these include birth weight, gestational age, head circumference, and weight for gestational age. In addition, many factors have not been controlled in looking at the at-risk infant.

PARTICIPATION

The selection of subjects to participate in a research project may in some ways bias the results. Lubchenco (1976) suggested that the handicapped preterm child is the one who receives the most follow-up and thus is more likely to appear in future studies. Therefore it is possible that results skew in the direction of seeing preterm children as more severely handicapped because they are the ones participating in the sample. Further, the percentage of possible subjects who do participate in a study versus those who do not participate can affect the results. Percentages of total possible subjects participating in the reported studies of LBW infants have ranged from as low as 42% to as high as 96%.

CONTROL OF THE SUBJECTS

In the early studies of the implications of being born at risk, subjects were generally not well controlled. They were chosen on the basis of one parameter, such as low birth weight. The researchers often showed little regard for other factors, such as socioeconomic status and prenatal and perinatal complications. A lack of careful control can mask differences that may be present simply as a result of the low birth weight variable. Further, many past studies excluded certain low birth weight subjects, such as those with the most significant handicaps. The ways in which subjects are selected—or left out—can have a major impact on a study's conclusions. For effective comparison, similar data have to be used.

CHANGING DEFINITIONS

Early studies defined low birth weight differently from later studies. The early studies (and even some recent ones) often considered all infants under 2500 grams as a group. In general, more recent studies distinguish between weight groups (using birth weight as a controlling variable), or they use only children

under about 1700 grams. Medical advances also bias studies. For example, mechanical ventilation was not available for children born before the 1970s.

DEFINITION OF "HANDICAPPED" OR "DIFFERENT"

Many studies have attempted to determine whether the LBW child is significantly different from the full birth weight (FBW) child. Researchers often choose subjects on the basis of statistical differences rather than significant clinical variables. These statistical differences can vary as little as three or four points on a standard intelligence test. In some studies, investigators base their definition on whether scores are within a normal range for the test. For example, one study may determine that a child with an IQ of more than 85 is average and not delayed, while in another study the author may choose a score of 90 or above to mean the same thing. Thus the same child could appear normal in one study and delayed in another.

AGES AT WHICH DEVELOPMENTAL ASSESSMENTS ARE COMPLETED

Some studies look at children at a particular point in time. Others follow the children for long periods of time. The results of children tested at 2 years may be difficult to compare with children tested at 4 months or at 10 years of age. Biological and environmental factors bear on each case differently and should be factored into an assessment.

MEANS OF ASSESSING DEVELOPMENT

Most of the very early studies used subjective measures of development. They collected the impressions of doctors, teachers, or parents. Recently, researchers have generally used more objective measures. Nonetheless, some articles published in professional journals as recently as 1985 have used only subjective measures.

The Question of Care

In looking at preterm children and cognition, three questions appear to be important to consider:

- Do pregnancy-related risks impose a long-term deficit on the mental development of the child?
- If not all cases are equally susceptible to risk, what factors determine which cases will recover and which ones will not?
- When and what type of intervention is proper for those children who will not recover?

Almost all of the studies on cognition have tended to use the global view of intelligence. Recently a few studies have begun to look at cognition as a number of distinct skills.

Cognition is a term frequently found in the current literature, but not every author applies the same meaning. To organize the development, intervention strategies, and outcomes of VLBW babies, cognition may be divided into several major areas, including:

Purposeful Problem-Solving: The child's goal-directed behavior.

Visual Pursuit and Object Permanence: The child's ability to visually track items in the environment and then realize that even if these things cannot be seen any more, they still exist. This leads to searching behavior as the child develops the skill.

Spatial Relations: The ability of an infant or young child to orient objects, persons, and oneself in appropriate relationships.

Causality: The ability that the child develops in the first two years of life to understand that he and others can cause actions to occur.

Audition and Vocal Imitation: The ability to hear things in the environment and respond to them appropriately, as well as to begin to imitate what is heard.

Gestural Imitation: The ability to imitate gestures seen in the environment.

Play/Schemes for Relating to Objects: Actions related to the development of symbolic behavior, including language. Development in this area shows the ability to differentiate between the various uses of objects. It also demonstrates the skill of using words and symbols to represent things that have occurred and are not immediately obvious.

Other aspects of cognition will not be covered because of the limited scope of the subjects in this manual.

Audition

Kurtzberg et al. (1979) studied 118 VLBW and 76 term infants who were evaluated at 40 weeks conceptional age on a task of lateral head-turning to human voice and non-speech sounds; 66% of the VLBW infants fell below the range of the term infants.

Wallace et al. (1982) did a follow-up of a sample of these subjects and found that there was a high correlation between the neonatal orienting response of the VLBW infant and measures of cognitive development involving language

at 6 years of age. Of further interest is the fact that these children were not severely impaired cognitively (Wechsler Intelligence Scale for Children—WISC—IQ mean: 101.1) nor did they exhibit significant hearing loss. The investigators suggested that subtle or transient auditory processing deficits during early infancy may influence the development of language-related cognitive functioning. In these infants, the visual and motor performance was uncorrelated with language-dependent cognitive measures.

Kurtzberg et al. (1984) studied 35 VLBW infants. The study compared the VLBW infants with 17 term infants, based on their responses to tone bursts and synthesized /da/ and /ta/ sounds. Recordings were taken at 1 day, 3 days, and 1, 2, and 3 months of age. At 40 weeks there was a significant difference between the two groups for speech sounds but not for tone. At the 1 and 2 month testing periods, there were no significant differences. As a group, this holds true. In fact, only one of the 35 VLBW infants showed a persistently deviant auditory-evoked potential.

It is not possible at this point to determine the lasting effect of early immaturity. However, the interactions of an immature neurological system that has been exposed to an acoustic environment much different from that of the term neonate might be a factor in determining speech. Further, a delay in maturation of the cortical areas concerned with the acoustic analysis of speech might result in impaired development of the environmentally dependent mechanisms of auditory processing.

Fox and Lewis (1983) compared preterm infants with no problems to term and preterm infants who suffered from Respiratory Distress Syndrome (RDS). The subjects included 30 term, 15 healthy preterm, and 18 RDS preterm infants. The RDS group exhibited significantly faster cardiac levels across stimuli. That group did not show a change in cardiac level across redundant trials, nor evidence of a response to the presentation of a novel stimulus. The two healthy groups demonstrated either evidence of recovery or discrimination of changes in speech sounds during a second novel transformation trial. RDS preterm infants did not exhibit this discrimination. (The investigators warn that it is important to include in a single sample only those preterm infants whose postnatal medical course is somewhat similar.)

O'Conner (1980) looked at 30 preterm (less than 2500 grams) and 20 term infants. Another 20 subjects were eliminated. The researchers found no difference in auditory discrimination between the two groups at 4 months of age. However, in follow-up studies, the difference between high scores and low scores on the Bayley Mental Scales could be adequately predicted by auditory discrimination in females, but the same was not true for males. They felt that the pertinent factors were attentiveness to stimulus and memory.

Visual Processing

Rose et al. (1979) found that preterm infants failed to show visual recognition memory on problems using three-dimensional shapes. Term infants showed significant novelty preference.

In a second study, Rose et al. (1980) showed the same differences between term and preterm babies on two-dimensional figures. However, at 12 months, the researchers saw no differences (Rose et al. 1978, 1979). Rose (1983) found that it took a significantly longer time to familiarize preterm infants with novel visual stimuli than term infants when both groups of infants were assessed at 6 and 12 months.

In general, visual processing studies have shown that preterm infants are deficient in visual recognition memory response to novelty and cross-model transfer up to 12 months of age. No long-term follow-up studies of these visual difficulties has been undertaken.

Means to Ends

Ruff et al. (1984) compared the manipulation of objects by preterm infants with that of term infants. The researchers matched behaviors such as looking, handling, mouthing, turning the object around, fingering, transferring from hand to hand, and banging. There were no differences between the preterm and term infants. However, when the preterm infants were divided into those who were high-risk and those who were low-risk, there were no differences between the low-risk infants and the term infants, but the high-risk infants showed less fingering, rotation, and transferring of objects. There was also a significant positive correlation with Bayley scores at 24 months. It related to a stronger degree than the 7-month Mental Development Index (MDI). The study of specific skills has begun, but there are no definitive conclusions yet.

Global Intelligence

Researchers studying global intelligence as part of the developmental consequences of low birth weight infants have reached some tentative conclusions. Low birth weight infants whose weight is above 1750 grams at birth are only minimally intellectually impaired, if at all. The following studies compared the outcome of LBW children (birth weights between 1750 and 2500 grams) with FBW children (over 2500 grams).

Robinson and Robinson (1965), in a comparison of 282 LBW children with 141 term children born in the years 1948-1951, found that there were no significant group differences on the Stanford-Binet, the Goodenough Draw-A-Person, or the Wide Range Achievement Test.

Harper (1959), in her study of 460 children under 2500 grams, found that there were no significant differences between preterm infants and their controls at 40 weeks adjusted age on the Gesell Developmental Scales. When assessed at 3 and 5 years, 84% of the LBW children were within or above the average range.

Weiner et al. (1965) and Weiner (1968) found a significant difference between the LBW and the controls. However, when they factored neurological elements such as abnormal reflexes out of the results, the findings were no longer significant. Even with the significant findings, 74% of the LBW infants were within the average range or higher.

Fitzhardinge and Steven (1972) compared IQ scores for a group of LBW and term children between 4 and 8 years of age. The average IQ for girls in the sample was 101. For boys it was 95. Both scores were within the normal range. Among the boys, 25% had IQs below 80. The differences in IQ between girls and boys may indicate that some boys have significant problems, but that does not demonstrate an overall delay within the group.

Drillien (1969) found that the mean IQ of those infants who weighed between 4½ pounds (2000 grams) and 5½ pounds (2500 grams) at birth was 103.

Rubin et al. (1973) and Neligan et al. (1976) found that FBW babies performed decisively better in tests than LBW babies. But even with these significant differences, the results supported the finding that the larger LBW babies function in the average range. In the case of the Niligan study, the researchers included children who were clearly handicapped as part of the study. This may have contributed to significant differences. McDonald (1964) found that when the study included children with obvious handicaps, differences in IQ scores were significant. Without them, differences were inconsequential.

Wright et al. (1972) looked at 65 matched pairs. He generally supported the findings of other studies. He further noted that among the pairs, in only nine cases did the preterm infants do better than the controls. In 31 pairs, the controls performed better than the preterms. In some cases the differences reached 20 points.

Jacobs et al. (1984) compared the performance of 3-year-olds on the McCarthy Scales of Children's Abilities. There was no significant difference between those under 2500 grams and the term babies.

In general, it has been found that for upper-weight LBW babies, IQ scores fall within the normal range. They are generally around five points lower than

those of their peers. (Caplan et al., 1976; Caputo et al., 1978; Weiner et al., 1965; Weiner et al., 1968; and Illsley and Mitchell, 1984.) It appears that these small differences continue into at least early adolescence and thus probably throughout the child's life.

Language Development

Largo et al. (1986) compared 114 high-risk preterm children with 97 healthy term children. Language data was collected in two ways: by having the mothers informally record the ages at which various developmental milestones occurred, and by using a Swiss-German version of the Illinois Test of Psycholinguistic Abilities for formal evaluation at 5 years of age.

Overall, the healthy term children reached most language developmental stages at slightly earlier ages than the preterm children who did not have cerebral palsy. The preterm children with cerebral palsy were more developmentally delayed than the other preterm children or the term children. When comparing the results at 5 years of age, there were no differences between the term and preterm boys, but differences still existed for the girls. At age 5, the correlation between SES and language development was significant for both term and preterm children. Again, it appears that the older the child gets, the more important the role of environment.

Washington et al. (1986) studied the language development of children at 3, 6, 12, and 18 months and at 4 and 6½ years of age. They concluded that there were significant differences in language skills even up to 6½ years of age. These included both expressive and receptive differences as well as differences in speech production. The differences were slight but were still considered quite significant.

Mental Retardation

There is an increased risk of significant developmental problems in the LBW group. Almost all of the studies reviewed found mental retardation among their subjects. McDonald (1964) showed that while the mean IQ for the subjects in the study was 96.8, thus supporting the notion of "within normal" IQs for the LBW subjects as a group, 2.7% of the subjects had IQs of less than 50. The general population would have only 0.4% below 50.

Douglas (1956) excluded 11 LBW children from a study because they were significantly impaired. Drillien (1964) found 35 cases of mental retardation in another study, with only one coming from the FBW group in the sample. Weiner's group (1968) disallowed 46 (approximately 10%) of the sample

because they were significantly delayed, but the study excluded only 17 of the children in the control group (about 4%).

Dann et al. (1958), Lubchenco (1976), and Wright et al. (1972) all found that approximately 44% of the LBW infants had IQs below 90, whereas one would expect only 26% in the general population.

Numerous retrospective studies have found a higher incidence of LBW children among the populations of mentally retarded studied. Asher and Roberts (1949) found that 24% of the student body of a special school for mentally retarded children had been LBW. This compares to the 7% of the general population (Cohen and Parmelee, 1983) who are born LBW. These findings are generally consistent with other early studies. (Pasamanick and Lilienfield, 1955; Rosanoff and Inman-Kane, 1984.)

Cerebral Palsy

The incidence of cerebral palsy has been reported to be as high as 10-20% in infants under 1500 grams. This compares to about 1% in the FBW population.

Learning Problems

Several studies have shown that LBW children who have IQs within the normal range experience more difficulty in reading (Caplan et al., 1976; Noble-Jameson et al., 1982; Rubin et al., 1973; Weiner 1968) and in mathematics (Rubin et al., 1973; Weiner, 1968) than full birth weight children. These comparisons have been made through early elementary grades, with the studies generally done with children anywhere from age 7 to age 10.

Wright et al. (1972) found that among those children born preterm who demonstrated IQs of 90 or above, 19% had average or good grades. In the term control group, it was 43%. Among the LBW children, 8% had all poor or erratically poor grades, as opposed to 5% of the controls. When both groups were compared (including those with all levels of IQ), 17% of the preterm children did not attend regular school, as opposed to none of the term children; 17% were failing, as opposed to 3% of the term children; and only 25% were above average, compared to 52% of the control group. The children were from 9 to 11 years old at the time of follow-up.

Kawi and Pasamanick (1959) found that 11.5% of a group of students who were reading at least two years below grade level had weighed under 2500 grams at birth, while only 4.6% of the control group had been low birth weight.

Grunau (1986) studied 320 school children (who had been LBW infants) during year three in school and compared them to a group of FBW children who had been in an earlier study. The investigators also compared them to a group of classroom controls (CC) who were selected from the same classrooms as the ones in which the LBW children were currently enrolled. The study suggested the following:

1. More children who had been LBW infants were placed in special education classes, special schools, or other types of programs than their term peers (17% vs. 3% in school year 3).
2. LBW children did not perform significantly more poorly on the standardized tests than the FBW children. However, the LBW children did perform more poorly than the CC children on the academic tests as well as on teacher rating scales.
3. When children who were diagnosed as having significant neurological abnormalities or as having IQs below 80 at 6½ years of age were excluded from the analysis, no significant differences were shown between the LBW and FBW children. Further, only in reading were there any differences between the LBW and the CC group.

Most of the studies reviewed showed that a higher than average percent of LBW infants will have developmental problems than their term peers, but remember that most children born prematurely develop normally.

There appears to be a correlation between birth weight and development, with lower birth weight projecting a poorer outcome.

Knobloch and her associates (1956) found that no infant with a birth weight under 2001 grams showed superior intellectual potential (as defined by the Gesell Scale) at 40 weeks adjusted age. Moreover, 17.6 % of the infants who had weighed less than 1500 grams at birth were then assessed as "defective" at 40 weeks.

Robinson and Robinson (1965) found that at 8 to 10 years of age, 24% of the VLBW babies in their study demonstrated significant delays, while only 3% of the LBW babies showed such delays. This 3% is only slightly higher than the 2% shown for the FBW controls, which represents what could be expected in the general population. Harper et al. (1959) and Weiner et al. (1968) noticed a significant trend toward the average IQ of the group declining as the birth weight of their study group decreased.

Eaves (1979) found that in the first year of life, those children of the group studied who weighed above 1750 grams scored significantly higher on test scores than did those who were born under 1750 grams. However, the study further noted that as the children got older, the differences tended to disappear.

Lubchenco and her colleagues (1976), in reviewing the literature, noted a significantly greater number of handicaps (both mental and physical) in those children who had weighed less than 1200 grams at birth compared to those who had weighed more than 1200 grams. This was true up to 10 years of age.

Braine et al. (1966) found that declining birth weight and a greater incidence of perinatal complications correlated with both an increasing number of very low-scoring, severely handicapped infants and a general downward shift of the curve. These data further suggest that none of the LBW infants of this study were left completely intact at 13½ months.

A number of studies have suggested that this relation exists, but no significant trends have been found by other authors. (Wright et al., 1972; Francis-Williams and Davies 1974; Dann et al., 1958.)

Holmes et al. (1984), in reviewing 16 studies of LBW babies, concluded that birth weight is a critical factor in the outcome of these infants. They found that the studies that failed to show significant delays examined infants under 2500 grams but more than 1500 grams. Those that examined infants born weighing less than 1500 grams all showed significant delays. Most of the studies Holmes et al. reviewed reported development only in the first 12-24 months.

The most obvious pattern emerging from the literature is that birth weight is a critical factor in determining developmental outcome in the first year of life. For later follow-up, the trend is not clear. The studies that have failed to show significant developmental delays have examined samples comprised of infants who weighed less than 2500 grams but more than 1500 grams at birth. On the other hand, in all the studies in which samples were limited to infants weighing less than 1500 grams, investigators noted evidence of significant developmental delay.

Some studies have challenged this concept. Siegel et al. (1982) found no significant differences between 2-year-olds who were born at 1500 grams or less and their FBW controls on either the Bayley Scales of Infant Development or the Reynell Developmental Language Scales. On the other hand, Jacobs et al. (1984) found that subjects who had weighed less than 1786 grams at birth performed more poorly than either those who had weighed above 1786 grams or the term controls.

Other studies have shown few problems when they have held other factors constant. Wilson (1985) compared VLBW babies with FBW babies. The children in this study were also controlled for head circumference. The normocephalic preterm and term groups did not differ significantly on the Bayley Scales of Infant Development at 24 months. The VLBW infants had a mean Mental Developmental Index (MDI) of 84, while the term infants had a mean of 91. The mean Psycho-Motor Developmental Index (PDI) of the preterm group was 99 and of the term group was 104.

Fawer et al. (1985) compared the outcome of 12-month-old LBW babies with and without intracranial hemorrhages. In those LBW babies with normal ultrasound results, only one of 29 had a developmental score below 90 on the Griffith's Scale. For those with isolated periventricular or intraventricular hemorrhaging, none of the 10 had developmental quotients below 90. In the third group, those with serious bleeds, 4 of 12 had scores below 80.

Studies such as these and others cited in this article raise a question as to the reason for the poorer outcomes in the LBW children in the studies cited previously. Since those studies did not control for factors such as those reported here, it is possible that the conclusions may be a result of other factors associated with lower birth weight, rather than just the birth weight itself. Further research is needed to demonstrate conclusively what the factors are.

Grunau (1986) compared children below 1750 grams with those between 1751 and 2041 grams and found that the lighter children had significantly poorer academic achievement and were also more frequently placed in special educational programs when examined after having completed one and three years in school. Even when the investigator made adjustments to equate any differences in the two groups in the social class of the children or the educational level of the mothers, the lower weight group still showed significantly poorer results for teacher ratings of reading, math, spelling, and writing. This suggests that there is a birth weight effect that is independent of social class and mother's education. However, when those children who had either IQs below 80 or significant neurological abnormalities were excluded from the study, the differences between the two low birth weight groups disappeared. This suggests that differences in the groups are a result of the smaller percentage who are significantly impaired (17%); for the remainder, the outcome is independent of birth weight.

Cognition in VLBW babies shows more delay in perceptual-motor areas than in verbal areas.

Caputo et al. (1978), in an analysis of the performance of children aged 7 to 9½ found that the only significant differences on the Wechsler Intelligence Scale for Children (WISC) scores between those born LBW and their FBW controls were picture completion, block design, and object assembly. These three subjects fit in the study as a factor called perceptual organization. These findings are further supported by Caplan et al., 1976; Weiner et al., 1968; and Wright et al., 1972.

Jacobs et al. (1984), using the McCarthy Scales of Children's Abilities on 3-year-olds, found that the term infants performed significantly better on the perceptual performance scale than the preterm infants. Further, the premature children did not perform as well as the term children on the Draw-A-Design.

There were no significant differences on the Verbal Scale, Quantitative Performance Subscale, General Cognitive Subscale, or the Memory Subscale.

Several studies have looked at Bender results, and all have found the preterm child to have difficulty. (DeHirsch et al., 1966; Caplan et al., 1976; Caputo et al., 1978; Weiner et al., 1968; Wright et al., 1972.)

When other perinatal factors can be held constant, birth weight does not appear to be a major factor in delay.

Parmelee and Cohen (1985), reporting on a five-year follow-up study using the Stanford-Binet Intelligence Scale, concluded that most of the infants with scores below 90 had previously had many perinatal problems. This is consistent with the findings of Drillien et al. (1980).

Fawer et al. (1985) looked at 54 preterm children who were 12 months of age corrected for prematurity who had varying degrees of intracranial bleeds. In comparing development, only those with severe bleeds produced significantly poorer results, this despite the fact that all were LBW.

Stave and Ruvalo (1980) divided the infants in their study based on three variables: length of pregnancy, size for gestational age, and medical risk factors. The study included the following groups:

- Term infants of average gestational age with few medical risk factors.
- Preterm infants of 28-32 weeks gestation who were of average size for gestational age and had few medical risk factors.
- Small for gestational age infants with few risk factors regardless of gestational age.
- Preterm infants who were average for gestational age but had high risk factors medically.
- Preterm infants who were small for gestational age and had been medically at risk.

There were no significant differences in the first three groups, but the last two groups showed a marked delay at 12 months in mental skills and an even more noticeable delay in motor skills.

Wilson (1985) looked at VLBW infants and found that when head circumference and head growth were controlled, there was no difference in development between FBW and LBW infants.

Illsley and Mitchell (1984) concluded that it is not the birth weight itself that affects the relative impairment of LBW children; rather it is the presence or lack of neonatal problems, and this is true for both small-for-gestational-age and preterm infants.

There is some disagreement as to whether or not developmental catch-up occurs in LBW children. However, it does appear that developmental movement in a negative direction is small, while there may be dramatic improvement upwards.

A number of studies have looked at children at several different ages. The results vary from study to study. Many of the differences may be attributable to the lack of control of the variables that affect eventual outcome, particularly sociocultural variables.

Douglas (1956) studied children who weighed less than five pounds at birth and followed them up at 8 and 11 years of age. There was a decline in the average IQ of the group from 8 years of age to 11 years of age, but the difference in scores was only four points.

Harper et al. (1959) compared the percentage of children who had IQ scores within the normal range at 40 weeks and then at 3 to 5 years of age. The study found that 97% of the infants were within the normal range at 40 weeks, but only 84% were within the normal range at the time they were tested between 3 and 5 years. This would suggest that 13% of the children had shown a decline in IQ over the time period.

Hunt (1979) showed that the developmental quotient of the VLBW child declined over time. For example, at 6 months, 12 of the VLBW children had developmental quotients above 100. By 4 to 6 years, none of the subjects had developmental quotients above 100. On the other hand, at 6 months only 8 subjects had developmental quotients below 80, but at 4 to 6 years, 22 had developmental quotients of less than 80. There is, however, some evidence in other studies to support the view that there is catch-up development.

Wilson (1985) studied twins and looked at the development of the twins over time. The twins were divided into various categories using birth weight, small for gestational age, and socioeconomic factors. Looking at each of the groups, Wilson found that over time, from 6 months to 6 years, the Mental Development Index Scores of the Bayley Scales and the Intelligence Quotient scores of the older children continued to increase. For example, the scores of the SGA children went from a mean of 91.4 at 6 months to a mean of 97.0 at 6 years. The course of the development was not consistent, however. Mean scores obtained at 12, 18, 24, and 36 months were lower than those obtained at 6 months. From 12 to 18 months, there was a consistent but small increase in the developmental quotients from 87.3 to 89.

At 3 years of age, the score was 85.4. It then rebounded to 97 at 6 years. The same was true for those children who weighed under 1750 grams. While these were the most impaired children, the Mental Developmental Index and Intelligence Quotients showed the same basic pattern. The mean score at 6

months was 74.3; at 12 months 73.6; at 18 months, 78.6; at 24 months, 82.3; and at 6 years, the score was 91.4. This suggests that even though the below-1750-gram babies are scoring in the borderline range early in life, the developmental quotients for the group as a whole eventually are within the normal range even without developmental intervention.

Wilson also looked at both a low and a high socioeconomic (SES) group. The findings were remarkably similar to the findings for the VLBW and the SGA group. At 3 and 6 years of age, there were significant differences between the two groups, but both groups showed the same basic trends. All showed marked improvement from 6 months to 6 years, with the low SES group going from 73.0 to 86.5, and the high SES group going from 76.8 to 101.1.

Eckerman et al. (1985) also studied the long-term development of children. She looked at VLBW infants under 1500 grams. Her subjects were divided into four groups, using head circumference at birth and head growth as variables.

- Group A. Microcephalic with poor head growth
- Group B. Microcephalic with good head growth
- Group C. Normocephalic with poor head growth
- Group D. Normocephalic with good head growth

Eckerman then looked at the developmental course of each of the groups at three time periods: 6 months, 15 months, and 24 months. Five patterns of development emerged. Pattern I showed no delays at any time. Pattern II was called late delay and showed normal development at 6 and 15 months, but delay at 24 months. Pattern III was called early delay and showed delay at 6 months but normal development at 15 and 24 months. Pattern IV, called early-late, showed delay at 6 and 24 months, but none at 15 months. Finally, Pattern V showed continuous delay over the entire time.

The following table shows the results of their analysis:

Percentage Showing Pattern

	I	II	III	IV	V
Group A	0	0	12	25	62
Group B	25	25	4	18	18
Group C	62	21	7	3	3
Group D	70	22	4	0	1

The majority of those not making progress or manifesting delays at 24 months showed poor head growth. There was no difference between the term and the VLBW babies when controlled for head growth.

DeHirsch et al. (1966) and Rubin et al. (1973) reported that there was a high incidence of language problems in children under 3 years in their studies. However, follow-up studies done at school age have generally found no differences between the LBW and FBW children. (Caputo et al., 1978, and Caplan et al., 1976.)

In summary, while it does not appear that there may be total developmental catch-up, studies show that there may be some slight decline or some increase in developmental scores over time for LBW infants.

Predicting Developmental Problems

Only a small proportion of children who are born at risk eventually have developmental problems, but in order to place a child in the right program, it is important to determine as early as possible which infants will manifest these delays. For the more severely delayed, the diagnosis can often be made very early, but for most children, prediction is not a clear picture. Three methods have been selected for making the determination: prenatal and perinatal problems, developmental assessment, and environmental factors.

PRENATAL AND PERINATAL PROBLEMS

A number of systems have been proposed for attempting to identify those infants who might have difficulty as a result of the perinatal insults of prematurity, and those who will develop normally. These systems have met with varying degrees of success in predicting developmental outcomes. The earliest studies, using the data from the Collaborative Perinatal Project (Broman et al., 1975; Smith et al. 1972), attempted to identify and classify children at risk for developmental problems. Broman was able to classify 48-73% of the children under consideration with low IQ scores at 4 years of age, but the system for prediction was very complicated and not practical for most clinical use. Further, identification of only 48% of a group does not meet the criteria for useful instruments. Smith was able to classify 76-83% of the children who would have difficulty at age 7 years, but that system also was considered cumbersome.

Siegel et al. (1982), in a prospective follow-up study, devised a system that used selected variables for making a prediction of which preterm children might not do well as they developed. The system was based on three types of factors: reproductive, perinatal, and demographic.

- The reproductive variables were birth order (gravidity), amount of maternal smoking during pregnancy (none, less than 10, 10-20, and over 20 cigarettes per day), and number of previous spontaneous abortions.
- The perinatal variables identified included the birth weight (with a lower birth weight having a higher risk value), one-minute and five-minute Apgar scores, gestational age, severity of respiratory distress (severe: assisted ventilation, X-ray evidence of respiratory stress, and/or oxygen levels higher than 80%; moderate: assisted ventilation, continuous positive airway pressure, and/or oxygen between 40% and 80%; and mild: oxygen less than 40%), asphyxia (a one-minute Apgar of less than 5 was defined as asphyxia) and apnea (a record was kept of the number of days during which apneic spells lasted longer than 20 seconds).
- The demographic variables were Hollingshead socioeconomic status, sex, and maternal and paternal educational levels.

Siegel and associates predicted accurate Verbal IQ scores at age 6 years in 73.2% of the children who had been evaluated. For Performance IQ, the percentage of correct predictions was 87.2%, and for the Full-Scale I.Q., it was 61.0%. (The prediction was based upon the ability of a child to score an IQ above 90.) Various types of miscalculations occurred. The largest error in all the groups was predicting that a particular child would function in the lower IQ range when in fact that child ended up functioning in the normal range (false positive). This occurred in eight of the 42 preterms for Verbal IQ, in four for Performance IQ, and in 16 for Full-Scale IQ. Only four infants who examiners predicted would be normal at age 6 years were found to be functioning in the delayed group (false negative). When the researchers applied this same procedure to the term infants in the study, all the errors in prediction indicated that a particular child would be normal when in fact that child was not.

It is encouraging that the largest errors were in the selection of children who were predicted to be delayed but who eventually were found to be normal. Based on the results of this system of evaluation, these children would perhaps be enrolled in programs for assistance, but there is no evidence that these programs would be harmful to a child. On the other hand, there may be some concerns that turn out later to have been unnecessary for parents who are told that their children are delayed, when in fact if these children were left to mature normally, they would have no developmental difficulties.

In spite of the common opinion that infants at risk are likely to have problems, Parmelee and Cohen (1985) found that prenatal and perinatal medical problems do not predict the outcome of individual infants.

Risk registers have been considered successful to some extent, but some other investigators have advocated a more simplified process of assessment.

DEVELOPMENTAL ASSESSMENT

Parmelee and Cohen (1985) suggested that a program that follows only certain risk groups would fail to identify many of those who will need intervention. They instead advocate mass screening late in the first year of life.

Parmelee and associates have suggested that if a single measure is to be used to identify those infants who need special help, the use of a behavioral developmental assessment late in the first year of life may be the most cost-effective means of identification. (Cohen and Parmelee, 1983; Parmelee et al., 1983; Sigman and Parmelee, 1974.)

ENVIRONMENTAL FACTORS

Parental Intelligence—Several studies have looked at the relationship between parental IQ and developmental outcomes. Rawlings et al. (1971) and Stewart and Reynolds (1974) found that LBW infants at ages 5 and 7 years had an IQ distribution similar to that of their parents.

Yeates et al. (1983) looked at the contribution of maternal IQ to the IQ of the LBW child. The comparisons were made at 24, 36, and 48 months. The scores were significant at each age level.

Home Environment—The Home Inventory (HOME) has been used to predict future outcome of children. (Siegel, 1982; Siegel, 1984; Yeates et al., 1983; Beckwith and Cohen, 1984.) In general, all of the studies suggest two major findings regarding the HOME.

- The use of the HOME is more highly correlated to developmental outcome when the HOME is administered after the child is 2 years of age.
- A child's later level of cognitive development is better predicted by the home environment than by prenatal and perinatal factors, or by infant developmental assessment.

Gottfried (1984) stated that the trend showed that later assessment of the home environment was more highly correlated with cognitive development than earlier testing.

Environmental factors influence the outcome of very low birth weight infants.

Socioeconomic Class—Grunau (1986) found that low socioeconomic class was a very significant factor in influencing the outcome of LBW babies. She found that only a small percentage of infants from higher socioeconomic classes were placed in special programs, while a relatively high percentage of those from lower socioecomomic circumstances were in special programs (9% vs. 29%).

Summary

Prediction is a difficult task, but findings suggest that medical risk factors may be the best indicator of problems in the first year. Environmental risk factors may become more highly correlated at older ages. Infant developmental testing seems to overpredict developmental deficits, but is helpful across ages.

Intervention

In considering intervention, two major questions must be considered.

- Who is in need of intervention?
- What form of intervention should occur?

WHO IS IN NEED OF INTERVENTION?

Most babies, even very low birth weight, will develop normally in terms of cognitive and language abilities, so it would be impractical and very expensive to provide intervention for all children who are born low birth weight. Medical follow-up until 18 months might be an effective approach. Children who from 9 months on show delay should receive developmental testing and assessment of their home environment. This will limit the number of children who use intervention resources unnecessarily. The children receiving services should be determined to be delayed, not merely at risk for delay. On the other hand, there are infants who very early on are at significant risk for developmental problems. For these children, intervention should occur as early as possible. The section on predicting developmental problems contained in this article may be helpful in identifying those children.

WHAT TYPE OF INTERVENTION?

With those infants for whom intervention is deemed necessary or appropriate, three major approaches have been used:

- Modification of the child's physical environment (generally focusing, at least initially, on the environment of the nursery).
- Stimulation of the infant.
- Assistance for parents to help them learn how best to assist their child.

MODIFICATION OF THE NEWBORN NURSERY

Many high-risk infants spend several weeks in an intensive care nursery where, because of the need for highly skilled medical care, the environment is considerably different from that for a child at home. One such difference is the very high level of noise and light in the neonatal ICU. Lawson et al. (1977) documented that light and sound levels in an ICU are around 75.2 decibels and there is little diurnal variation in either light or sound. Because they must care for many critical children at the same time, the staff of the nursery cannot easily respond to the needs of a particular child. It may take a considerable time to get to a child who is upset or hungry. Further, because of the special care that must be provided, an infant may be awakened often for medical purposes, thus disturbing the baby's wake-sleep cycle.

Even routine medical and nursing procedures provide sources of noxious stimuli, suggested Long et al. (1980). Certainly most of the procedures of the high-risk nursery are essential, but when possible the staff should note which ones are detrimental to the well-being of their charges and change them. An example of an undesirable procedure is the use of closed isolettes. The closed isolette helps maintain the infant's body temperature and shields the child from infections, but it reduces the opportunity for human contact. In contrast, the use of heated open beds, along with the caregivers washing their hands and wearing gowns, can help the staff provide the medical care needed, while allowing more human contact for the infants.

Campbell (1980) suggested the following medically sound reasons to modify the NICU environment:

- To decrease overstimulation of the infants.
- To avoid unnecessary handling during periods of quiet sleep.
- To introduce diurnal rhythms to promote behavioral organization.
- To provide some contingent tactile and kinesthetic responses to the infants' stress signals.
- To accommodate social interaction stimuli (auditory, visual, tactile, kinesthetic) during alert periods.
- To terminate or at least alter stimulation that produces avoidance responses.
- To establish individualized programs based on assessed needs.

INFANT INTERVENTION

The most common type of infant intervention programs are those that treat the child directly. These include such activities as massaging the child's body or stroking it. (Rose, 1980; Rice, 1977; Rose, et al., 1980.) Other programs have focused on auditory or visual stimulation (Scarr-Salapatek and Williams, 1973; Groom, 1973), or tactile and vestibular stimulation (Brown et al., 1980). Rocking as a means of vestibular stimulation has also been used (Leib et al., 1980; Neal, 1968; Kramer and Pierpont, 1976; and Korner et al., 1975).

Almost all of these studies of intervention programs have shown some improvement in the children's cognitive development. In general, the length of follow-up in these studies was only two years. In those cases where controls who received no intervention were used, there were significant differences. However, as Campbell (1980) reported after reviewing 14 studies, only six used standardized test measures. Of those studies using this type of data, five demonstrated significant effects. For psychomotor development, all of these children were followed for a year or less. It is therefore not certain whether the effects were long-lasting or not.

Despite studies that showed significant differences when comparing low birth weight babies with controls, Campbell's (1980) review of several studies concluded that intervention was not warranted. Her reasons were as follows:

- Too little evidence exists on how to achieve maximal and optimal effects from an intervention program; the variables responsible for success have not been defined.
- Insufficient documentation is available of actual infant responses to intervention and of possible adverse side effects.
- The successful experiments involve much post-discharge intervention. The programs that result in the strongest effects on multiple areas of development can be so costly to implement that most centers cannot attempt them. Furthermore, these programs may be successful primarily because the parents receive support in their own homes.
- No evidence exists on the effectiveness or safety of intervention for those infants most at risk for developmental deviance.
- Most reported studies were designed around a model of the preterm infant as an isolated, deprived organism. New studies on the ecology of the high-risk infant suggest that a better, more complex model should be tested.

FAMILY INTERVENTION

The goals of this type of intervention program are generally designed to help parents learn how to handle their child and to feel more comfortable in interacting with their baby. Studies show that family intervention is generally successful in fostering parent-child interaction. (Field et al., 1981; Metzl, 1980; Bromwich and Parmelee, 1979.)

MacPhee et al. (1984) suggested that family intervention is the most important type. They point out that, particularly for low-income and stressed families, life circumstances must be addressed first. When a family is able to meet day-to-day needs, they may be able to assimilate information about child development and ways to stimulate the child. The curriculum for parents might consist of the following points:

- Contingent verbal responsiveness, regardless of the content, to the child's overtures. Older siblings and parents can enhance cognitive development through verbal interaction with the child.
- Active, mutual participation in intellectual activities such as reading, playing social games, and using toys. Because solitary play does not appear to be very beneficial, the use of playpens or TV as a babysitter should be discouraged.
- A warm, responsive relationship could be fostered by showing parents how to have fun with their babies. At earlier ages this might involve give-and-take social games. Later in a child's development, mutual activities such as cooking, storytelling, and playing could be the vehicles for parental involvement.
- Disciplinary techniques that emphasize reasoning, consistency, and behavioral control could be provided. These are more beneficial than either restrictive or permissive approaches.

This type of training may be of assistance to all parents, not just those with at-risk infants. Such a program might be established within the hospital for parents of *all* children born there. The period of confinement within the hospital is the best time to offer it, because the parents of newborns are probably the most receptive to this type of information. If parents are aware of what to look for, they can assist in detecting developmental problems. This applies not only to high-risk infants but to all babies.

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Neuromotor Development

by Melody Borland, M.L.A., P.T.

Abstract

Assessing and treating VLBW infants is a fairly new and highly specialized area of research and clinical practice for physical and occupational therapists. Although questions remain regarding the nature and extent of the responses of VLBW infants to intervention, information in the literature indicates that intervention may provide significant benefit in some areas of functioning.

The specialized nature of this area requires that physical and occupational therapists have a thorough knowledge of normal infant development and intervention skills pertinent to working with this population. It also requires that therapists have a base of knowledge about preterm infant development and special skills to differentiate between normal and abnormal development.

Knowledge about VLBW infants is expanding rapidly. As awareness increases, the basis for establishing intervention in the special care nursery will become more apparent. Physical and occupational therapists have the opportunity to add to the information about the VLBW infant and to develop and evaluate the benefits of intervention.

Neuromotor Development

Both physical and neurological development begin at conception and follow a normal progression through the gestation period, infancy, childhood, and beyond. The age of the infant or child is always important in a physical and neurologic assessment; and this may be especially true for preterm or VLBW infants. There are major differences between term and preterm infants, and

accurate assessment requires a thorough understanding of normal physical and neurologic development based on gestational age.

Examining the Newborn

ESTABLISHING GESTATIONAL AGE

There are several methods for calculating gestational age at birth. Casaer and Akiyama (1970) cite the following:

- Conceptional age is calculated from the time of conception.
- Postmenstrual age of the infant is calculated from the date of the mother's last menstrual period.

Many VLBW infants are born to mothers who remember neither the date of conception nor the first day of their last period. When both conceptional age and postmenstrual age are calculated, there may be a variance of plus or minus 2.5 weeks between methods. Individual differences in menstrual cycles account for any discrepancy.

The pioneering efforts in studying newborn neurology by Andre-Thomas and Saint-Anne Dargassies (1960) and Saint-Anne Dargassies (1955) in France and Prechtl and Beintema (1964) in the Netherlands led to the publication of two classic works. Prechtl and Beintema originated the neurologic examination of the term newborn, and Amiel-Tison (1968) developed the estimation of gestational age from neurologic development.

Criteria for establishing the gestational age of healthy newborns were also developed by Finnström (1972) and Dubowitz and Dubowitz (1977). However, some of the neurologic criteria developed by these authors may be quite questionable when used with sick infants since Ballard et al. (1979) found that hypotonia lowers scores and hypertonia raises them.

Farr (1966) and his group reviewed physical and other external criteria useful in determining gestational age, including skin color, texture, and opacity; edema; lanugo; ear form and firmness; genitals; breast size; nipple formation; and plantar creases. They developed a method of measuring and scoring these characteristics to determine gestational age. As physical characteristics become more developed, scores increase and age estimation increases correspondingly.

According to Lubchenco (1976), neurologic development is more predictable than physical development and is less affected by alteration of the intrauterine environment. Both methods have been found to be useful in predicting gestational age at birth.

Dubowitz et al. (1970) combined neurologic criteria with external or physical signs. With this combination they developed a scoring system for clinical assessment of gestational age in the newborn.

ASSESSMENT OF THE TERM INFANT

Prechtl (1977) was among the first to study the neurologic examination of the newborn. Parmelee and Michaelis (1971) attempted to develop a system of infant assessment that combined behavioral and neurologic criteria.

The first major neurobehavioral examination of infants was developed by T. Berry Brazelton in the Brazelton Neonatal Behavioral Assessment Scale (BNBAS 1973). The BNBAS is more of a behavioral measure than a neurologic examination. It is intended for use with 40-week gestation term infants. The scale is complex: it contains 26 behavioral criteria and 20 reflex criteria. The development of the BNBAS marked a significant advance in infant assessment. It also highlighted the need for a similar assessment for preterm infants.

ASSESSMENT OF THE PRETERM INFANT

The need for a formalized way of examining preterm infants prompted Als (1980) and her colleagues, including Brazelton, to develop the Assessment of Preterm Infants' Behavior (APIB). Brown (1981) noted that the APIB is a modification of the BNBAS. It assesses differences in the capacity of infants to regulate and integrate their behavior. This scale is rising in popularity as its use by health care professionals increases. Research thus far indicates that the APIB is a useful testing instrument.

An adaptation of the BNBAS was developed by Horowitz et al. (1978). This is the Neonatal Behavior Assessment Scale with Kansas Supplements (NBAS-K). Subsequently, the authors of the NBAS-K developed another modification to assess preterm infants. This is the NBAS-Kansas Assessment of the Preterm Infant (NBAS-KAPI), which Schwartz et al. (1985) note is in preparation.

Dubowitz and Dubowitz (1981) developed a combination of neurologic and behavioral items. This procedure can be performed on an infant as early as 28 weeks gestation within 24 hours after birth, noted Prechtl (1977). Dubowitz (1985) cited other reasons for the use of this assessment device:

- It can provide a means to study the preterm infant under normal and abnormal conditions.
- It can help to identify and document the effects of perinatal insults on the newborn infant.
- It provides a means of following sequentially the resolution of abnormal neurological signs and detecting new abnormalities.
- It may provide some guide for prognosis.

BEHAVIORAL STATES

Behavioral states that appear in all infants range from deep sleep to wakefulness and crying. Observation and measurement of infants in these states also provide information about muscle activity, levels of oxygen, blood pressure, heart rate, and other variables. (Nijhuis et al., 1982; Casaer, 1979; Prechtl and O'Brien, 1982.)

Following is a description from Casaer and Eggermont (1985) of each of the five behavioral states of the neonate 36 weeks or older. These states differ somewhat from the six states described in the Brazelton Scales. Brazelton's State 3 describes a drowsy state between light sleep and alertness.

State 1— A State 1 interval begins when respiration becomes regular in an infant who keeps the eyes closed. Sighs or short apneic spells occur, but the respiration returns rapidly to regularity. Marked irregularities are always transient and connected with short-lasting gross motor activity. Eye movements under the closed eyelids are not observed. The infant remains in a rather stable posture. Spontaneous clonus can occur in extremities or at the jaw. Rythmical mouthing movements appear for a period of seconds lasting up to a maximum of a few minutes, with each burst taking place for 10-20 seconds and the rate increasing to 60 movements per minute. Gross movements are rare, but very stereotypic startles do occur and they last for a maximum of one or two seconds.

State 2—The onset of State 2 after an awake state is determined at the moment the baby closes the eyes. If respiration was regular while awake, it becomes somewhat irregular; furthermore, if an antigravity posture was present while awake, this posture will disappear either gradually or stepwise after each body movement during the onset of sleep. The transition from State 1 to State 2 is frequently marked with a startle, with gross movements, or at least with a sigh. The respiration is irregular and apneic spells may occur, frequently announced with gross movements. Under closed eyelids, slow eye movements can be observed immediately after the onset of State 2. The typical rapid eye movement appears 1-4 minutes later.

Small twitches are common in State 2; they are visible in the face, hands, and feet. Grimaces, smiles, and rhythmical mouthing are observable at times. Gross movements of one limb or generalized body and head movements are the most characteristic transient events in State 2. Startles do occur, but they are less forceful and less stereotyped than in State 1. The many movements result in frequent changing of postures. In quiet intervals of State 2, the postures are the farthest away from the antigravity postures seen in the awake states and also in State 1.

State 3—In State 3, the baby lies still and keeps the eyes open. Although there may be moments of staring, most of the time the infant seems to scan the

environment with rapid eye movements. The baby frequently shows a stable posture, and respiration is regular. State 3 intervals can be very short, lasting only a few minutes. The longest periods occur after feedings. Shorter periods happen within State 2 periods (for example, awaking during sleep), or as short periods during awake states, preceded or followed by States 4 and 5.

State 4—The infant in State 4 has the eyes open and moves arms, legs, and head. In the prone position, the head lifts and some locomotion does occur; in the supine position, limb movements are frequently less patterned. Periods with large and small movements alternate; respiration is more irregular during times of large movements. Postures change frequently.

State 5—The major characteristic of State 5 is crying. An infant's cry is a communication signal, and mothers, nurses, and other caregivers learn to discriminate among discomfort, hunger, and pain cries.

With the advent of real-time sonography, observation of behavioral states in utero became possible. In 1982, Dawes et al. concluded that "the essential feature of normal fetal heart-rate variability in the last trimester is best characterized not by the presence of accelerations, nor absence of decelerations, nor by any overall measure of variability, but by the detection of intermittent episodes of high and low heart-rate variability reflecting changes in fetal state." Before this study, documentation of cycles of sleep, activity, and rest did not seem to be well defined. (Parmelee and Schultz, 1970; Prechtl et al., 1979.) A striking resemblance exists between the behavioral states of the fetus in utero and of the preterm infant in the nursery. Visser et al. (1982) defined four fetal behavioral states that parallel the first four states found in the neonate of 36-38 weeks gestation or greater. State 5 is characterized by crying and is not found in utero.

By 36 weeks gestation, behavioral states are well established. Casaer and Eggermont note that any baby 36 weeks gestation or older who cannot be placed in any one of the five states is sick or influenced by medication.

Implications of Infant Development for Physical and Occupational Therapists

Physical therapists and occupational therapists working in the Neonatal Intensive Care Unit clearly need to be familiar with the means of assessing preterm and VLBW infants. Special attention to behavioral states is advised.

Lubchenco (1976) reported that developmental stages progress the same in utero as outside the uterus in the preterm infant, but there are some differences in preterm and term infants assessed at the same conceptional age. A term newborn automatically walks on the entire sole of the foot in a heel-to-toe

pattern. A 40-week-old infant who was born preterm typically walks on the toes in a toe-to-heel pattern.

There are differences between the term infant and the preterm infant even when both are compared at the same conceptional age. For example, according to Michaelis et al. (1973), the term infant quickly shifts from a sleep state to an active awake or crying state when handled and cries more than the preterm infant in the same situation. The preterm infant can be maintained at a lower state level during handling.

In the supine position, infants of 40 weeks gestational age who were born preterm exhibit less flexion than their term counterparts. Dubowitz (1985) noted that when they are held in ventral suspension, these preterm infants demonstrate more extensor tone and therefore better head control and leg extension. According to Palmer et al. (1982), there are other criteria that show this difference in neurologic development.

Aylward (1982) has reported that preterm infants have increased extensor tone, poorer head control, and a general lack of ability to modulate behavioral states when compared to term infants of the same age. A study reported by Telzrow et al. (1982) observed fewer hand-to-mouth behaviors in preterm infants than in term infants.

Maturation of the Preterm Infant

The field of neonatal medicine is relatively young, and information about the neurologic and behavioral maturation of the preterm infant is rapidly changing. Information about the preterm infant is increasing, and patterns of maturation are becoming more clear. The following chart is a compilation of information gathered from reports by several investigators. Although fetal viability outside the uterus generally begins at about 28 weeks gestation, some information pertinent to earlier stages of gestation is included. Extremely preterm babies of less than 28 weeks gestational age are surviving more often than previously. (Saint-Anne Dargassies, 1966 and 1979; Prechtl et al., 1979; Lubchenco, 1976; Amiel-Tison, 1968; Dubowitz and Dubowitz, 1981.)

NEUROLOGICAL AND BEHAVIORAL MATURATION

20 Weeks Coordination of sucking and swallowing movements usually occurs in the infant by this time.

Turning of the head stimulates arm movement on the face side. This is the beginning of the asymmetrical tonic neck reflex.

22 Weeks Hypotonia appears.

Movements are slow and usually involve the entire body with the exception of face muscles.

Diaphragmatic contractions are visible.

Rooting reflex is very incomplete.

24 Weeks Slow but active movement of hand to face occurs.

Trunk and feet exhibit more rapid and brief spinal reactivity.

26 Weeks Upper limbs are more active.

Occasional alternating flexion and extension in lower limbs occurs.

Isolated lateral head movements appear.

27 Weeks Effective respiration can be maintained, but central nervous system control is not developed.

28 Weeks There is an appearance of alertness or awareness.

Response to light of varying intensity is purely motor; palpebral fissures close and/or the intensity of closure increases.

Pupillary and doll's eyes reflexes are not seen.

Eyes do not move toward soft light.

Response to auditory stimulation is misleading (directly related to excitability of the infant).

Smell is produced only by volatile substances that act on the infant's trigeminal nerve endings.

Taste is expressed appropriately by repulsion or attraction.

Touch and pain are well differentiated. Responses to tactile stimulations are immediate when in an alert state.

Sleep, torpor, and wakefulness alternate.

Skin and internal temperature are influenced by ambient temperature.

Motor reactions evoked by sensations of cold and heat are adaptive.

Neither hunger nor thirst are manifested.

Respiration varies with state of infant, who may still show periodic breathing and short periods of apnea associated with bradycardia.

Sucking response is obtained, but it is weak and not coordinated with the infant's swallowing.

Genital physiologic function may occur.

Rooting, trunk bending, and crossed extension are all random and purposeless.

Rooting—lateral response must be aided by holding head—lips only are involved.

Moro reflex is weak and cannot be elicited routinely.

Resting posture is the total extension of four limbs. Head rests on the side of the infant's face.

Marked hypotonia appears in all parts of body; however, it is in the distal ends of lower limbs that a gradual increase in tone is observed.

Grasping is present but is weak.

Tonic response of the lower limbs produces slow, sustained extension of the infant's knee joint.

Repetitive movements occur in upper limbs, which have catatonic appearance.

Movements are more frequent in lower limbs.

Trembling is still common in the infant.

Spontaneous motility consists of bursts of activity followed by absolute rest.

30 Weeks

Waking phases are more numerous.

Eyes remain open; pupillary and doll's eyes reflexes can be noted.

Visual fixation and orientation occurs.

Sucking and swallowing echo respiratory rhythm.

Cry is prolonged and well maintained.

Quick movements are more frequent.

Broad smile can be seen during digestive euphoria.

Rooting reflex is complete. There is no need to hold head. Head extension is added to lateral response.

Grasp reflex is firmer.

Straightening in upright position remains confined to lower extremities.

Active muscle tone is first noted by lower extremity extension after stimulation to soles of feet.

Resting posture is shown by four limbs extended. Chin touches acromion.

When limbs are lifted and released, there is a slight rebound.

32 Weeks

Sucking is synchronized with swallowing.

Alertness appears spontaneously.

Waking can be completely dissociated from phases of motor activity.

Doll's eyes reflex, dazzle reflex, and pupillary light reflexes are all present.

Rooting, grasp, Moro, and walking reflexes are all complete, but crossed extension remains feeble and incomplete.

There is extension of the upper limbs and outline of flexion.

There is extension of the infant's upper limbs and slight knee flexion. Chin is inside acromion.

Gradual increase in muscle tone continues an upward spread and reaches the trunk and thighs.

Infant will straighten legs if placed in standing position.

Generalized motility is dominated by vigorous movements of whole body, especially trunk.

There is the disappearance of limp, passive fall of legs when released.

Irritability disappears.

Hand-face orientation and hand-to-mouth begins.

34 Weeks Sucking and swallowing are strong enough to sustain nutrition. Infant can suck from bottle.

35 Weeks Frog-like position appears in the infant: legs flexed, thighs abducted, arms extended.

Straightening of lower limbs induces straightening of trunk. Plantar support is solid. Hypertonia exists.

Trunk straightening is still laborious.

Excellent recoil of legs appears along with excessive hypotonia of arms with limp, passive fall.

Pain response at level of face involves muscles of rotation of neck.

Head-straightening reflex is now a slow reflex.

Crossed extension is well developed in all phases but adduction.

Rooting is in three phases: lateral, repetitive, and extension of head. Lips, tongue, and head participate.

36 Weeks Behavioral state can be considered now.

Infant lies in flexion in all extremities. Arm flexion can be inhibited by holding in extension for 30 seconds.

When soles of feet are stimulated in upright position, neck extensors and flexors will right the head and trunk.

Finger grasp is strong enough to pull infant off surface.

Visual fixation and orientation are fully mature, like a 40-week infant.

37 Weeks Rooting shows improvement by the addition of head flexion, but it remains limited.

Recoil in arms is possible but is inhibited by slow, prolonged downward extension.

Neurological picture comes close to term infant.

All four limbs are in flexion—chin is well ahead of acromion.

Straightening responses involve whole body.

Grasping is steady and firm.

Motility is less than that of a more preterm infant.

Rotation of head and passage of arm occurs in front of shoulder when the infant is prone.

There is spontaneous active orientation of the eyes and head toward soft light.

Vigorous, firm cry is well maintained and of average tonal quality.

Alertness is of poor quality.

Crossed extension still will not complete by easy adduction and toe-fanning.
Hypertonia is generalized and interferes with movement.

38 Weeks Arms return to flexed position even after being held in extension for 30 seconds.
Shows slightly less hypertonicity than term infant.
Rights legs and trunk and holds head for few seconds.
When pulled to sit, the head follows trunk and keeps in line with the infant's body momentarily.

41 Weeks There is brisk, sudden recoil of limbs.
Muscular hypertonia reaches upper limbs, with equal and powerful flexion in all four limbs, and chin rests near sternum.
Tonicity of extensors and flexors of neck is nearly equal in all four limbs.
There is good alertness.
Crossed extension is complete.
When pulled to sit, head goes in line with trunk.
Rooting exhibits as all four phases equally. Head movements are easy in all four directions.

Research on Intervention in the Special Care Nursery

A number of studies indicate that stimulation of preterm infants in the Neonatal Intensive Care Unit (NICU) has a positive effect on cognitive development and growth (weight gain) in the first year.

A physical therapist (Piper et al., 1986) reported on a randomized controlled trial of the use of neurodevelopmental therapy initiated in the nursery and continued for 12 months. The subjects were infants at very high risk for neurological sequelai. The therapy did not alter the pattern of motor development in the experimental group.

In a review of studies on the effects of intervention with preterm infants, Suzann Campbell (1982) concluded that intervention does not affect their motor development. She postulates several possible explanations:

- The intervention programs are typically designed to promote social interaction and cognitive development but may not be tailored to have an effect on gross motor performance because rocking and passive movement do not stimulate active motor responses sufficiently.
- Low SES families may, even without intervention, provide sufficient stimulation to facilitate their infants' level of motor development, resulting in no differences between experimental and control groups.

- The Bayley Scales of Infant Development may be insufficiently sensitive to measure differences in motor performance between groups. Large age differences between items are typical of the Bayley Motor Scale and may make it insensitive to small but significant differences in developmental level. The test also assesses only the achievement of motor milestones in the first year and cannot reflect possible variations in strength, coordination, and endurance unless they are significant enough to affect achievement of gross motor milestones.
- Motor development may be more dependent on preprogrammed maturation of the neuromuscular systems than on environmental influences and thus be less subject than cognitive development to the effects of an intervention program.

Whatever the reasons, the paucity of studies in the literature by physical therapists and others with expertise in the design of programs to facilitate motor development suggests the need for further research on the effects of early intervention on motor performance.

Questions on intervention arise, but not all the answers are available yet. They do, however, provide interesting topics for further research. Should NICU intervention be provided routinely and if so, what is most appropriate? Who should provide this intervention? Should all infants receive the same intervention regardless of age, weight, or illness? How will the efficacy of such programs be documented? Are there long-term positive effects from such intervention?

In Campbell's judgment, routine provision of NICU intervention is not justified. She cites several reasons for this:

- Too little evidence exists on how to achieve maximal and optimal effects from an intervention program; the variables responsible for success have not been defined.
- Insufficient documentation is available of actual responses to intervention and possible adverse side effects.
- The most successful experiments have involved large amounts of post-discharge intervention. (Scarr-Salapatek and Williams, 1973; Field et al., 1980.) Those programs that result in the strongest, across-the-board effects on multiple areas of development would be too costly for many centers to implement. In addition, these programs may be successful primarily because of the extensive period of support for the parents in their own homes.
- No evidence exists on the effectiveness or safety of intervention for those infants most at risk for developmental deviance.
- The majority of reported studies were designed around a model of the preterm infant as an isolated, deprived organism. New studies on the ecology of the nursery environment and on the competencies of the high-risk infant suggest that a better, more complex model should be tested.

Als (1986) found that research on a model of individualized environmental care for VLBW neonates resulted in less time on respirators and earlier normalizing of feeding in the experimental group. Multiple environmental modications were made for such things as decreasing noise and lighting, and being very gentle in handling. She has developed a training program called Neonatal Individualized Developmental Care and Assessment Program (NIDCAP). For further information on NIDCAP, contact Dr. Heidelise Als, Director of Neurobehavioral Infant and Child Studies, The Children's Hospital, 320 Longwood Avenue, Boston, MA 02115.

IMPLICATIONS OF THE RESEARCH

The safety of the infants and the effectiveness of intervention should be of primary importance for therapists evaluating and treating VLBW infants. Dickson (1981) noted that there is very limited research on appropriate assessment and treatment techniques for this population. Thus little information exists on safe and effective intervention.

Anderson and Auster-Liebhaber (1984) suggest that "neonatal intervention is a highly specialized area of physical and occupational therapy clinical practice" and "entry-level therapists have not had the opportunity to develop the appropriate experiences and treatment skills." They indicate the need for knowledge of normal development and the ability to differentiate normal from abnormal preterm development. These investigators cite a number of skills necessary to provide NICU program intervention, such as familiarity with the operation of ventilators and cardiac monitors, knowledge of signs of physiologic stress, and the ability to implement immediate intervention.

The surroundings of the NICU are nothing like the newborn's former intrauterine environment nor like the conditions the infant will experience at home. (Lawson et al., 1977; Gottfried et al., 1981; Newman, 1981.) Noise and light levels in the NICU vary but certainly are higher than what the fetus experiences in utero. In general, these levels are higher than in the newborn nursery for term infants. (Barnard, 1973; Lawson et al., 1977; Masi, 1979; Parmelee, 1981.) The best environment to copy for intervention purposes has not been established. (Cornell and Gottfried, 1976; Field, 1980; Masi, 1979.)

The infant in the NICU must somehow deal with pain-producing stimuli that are needed medically to sustain life. The effects of such stimuli on the infant are not known. Even the adverse effects of handling are not completely known. Als (1981) reported that the self-regulating strategies for consolation are expensive and not well defined for preterm or VLBW infants. Self-regulating behaviors include hand-to-mouth, clasping hands, or sucking on fingers. They may become overly stressed with handling and exhibit signs such as clenched fists or splayed fingers, tension or limpness, changes in respiration, strained facial expressions, hiccoughing, cyanosis, a bowel movement, or spitting up.

These infants often are more sensitive to environmental input and need more assistance in returning to a balanced state.

Schwartz et al. (1985) noted that this difficulty with behavioral state regulation exists for some time after discharge to the home environment. Parents of VLBW babies have to care for infants who behave differently from the term infants they had expected. This behavioral difference may affect early childhood intervention programming, and program personnel should be sensitive to this type of problem.

Intervention Models in the Special Care Nursery

Review of the literature of intervention programs in the NICU or Special Care Nursery reveals that most of the research involves the additional stimulation for the preterm or VLBW infant caused by being in a special care nursery.

Campbell (1982) detailed characteristics of a NICU intervention program:

- Modification of the environment to decrease overstimulation.
- Avoidance of unnecessary handling during periods of quiet sleep.
- Introduction of diurnal rhythms to promote behavioral organization.
- Provision of contingent tactile and kinesthetic responses to stress signals.
- Allowing for social interaction stimuli (auditory, visual, tactile, kinesthetic) during alert periods.
- Immediate termination of or alterations in stimulation that produces avoidance responses. (This may include social stimuli.)
- Establishment of individualized programs based on assessed needs.

Of the above seven characteristics that Saint-Anne Dargassies (1955) reported, all but the introduction of diurnal rhythms can be provided in part by the physical or occupational therapist in the NICU.

Reports of therapy programs in NICUs by Dickson (1981) and Anderson and Auster-Liebhaber (1984), note that common procedures and objectives include:

- *Referral* by NICU personnel (physicians, social workers, nurses).
- *Review of records* (maternal, family and social, infant).
- *Assessment* for detection of abnormalities such as developmental delay, for possible deviations that put the infant at risk for later delay, for confirmed neurological deficits such as spina bifida or brachial plexus injuries, and for congenital malformations.
- *Treatment* using neurodevelopmental principles (Bobath, 1969) to facilitate more normal developmental patterns, standard joint range of motion exercises, inhibition/facilitation techniques familiar to most therapists, oral motor stimulation, and chest physical therapy.
- *Parent education* to assist in the parent-infant bonding or attachment process by teaching techniques for handling these infants. There must be some

coordination with other NICU personnel who are providing similar parent support to avoid duplication of services. Encourage parents to observe and be a part of treatment sessions. The investigators report that involving parents in this process produces positive results.

- *In-service* training for NICU personnel.
- *Follow-up* of infants after discharge from the NICU. Some infants are referred directly to developmental intervention programs. Some are provided with home stimulation programs. Others are followed through regularly scheduled high-risk or VLBW clinics. A variety of personnel complete periodic developmental assessments through these clinics.

Physical and occupational therapists find their roles have expanded into the NICU. A number of questions arise because of this. Are hospital therapists, who generally do not have extensive developmental or pediatric experience, the most appropriate to work in the NICU with VLBW infants?

Therapists who are employed in early childhood development intervention programs may have the expertise and desire to work with the NICU population, but there are obvious hospital policy problems associated with this. What seems to be indicated is for the skills of hospital therapists to be upgraded or to allow therapists with the necessary developmental expertise access to the Special Care Nursery.

Assessment and Treatment

TREATMENT PRINCIPLES

Many general principles and skills for working with term infants apply to preterm babies as well. However, the current level of knowledge of the behavioral and neurologic development of preterm or VLBW infants mediates against the definition of a formal approach to treatment.

This portion of the article presents some concepts to consider when working with the VLBW infant. Information in the chart of normal preterm development in the previous section provides a basis for understanding the neurologic picture of the VLBW infant.

BEHAVIOR OF THE PRETERM OR VLBW INFANT

In assessment and treatment, the examiner must carefully observe the infants' behavioral states and their responses. According to Casaer and Eggermont (1985), certain independently occurring cycles of activity are present in the preterm infant. Before 36 weeks gestation, the cycles include times of activity and quiescence along with intervals of regular and irregular breathing and periods with REM (rapid eye movements) and without REM.

It is not clear from this review of the literature that therapeutic intervention must occur during a particular behavioral state to be effective. Touwen (1976) indicated that infants should be examined only at appropriate times: during States 3 and 4. The VLBW infant does not achieve these states until 35 to 36 weeks gestational age. Thus intervention would be postponed in these infants if it depends upon their behavioral state.

As reported by Als et al. (1980), the inclusion of items such as quality of responsivity, cost of attention, range and flexibility of states, and other factors on the APIB suggests that treatment needs to be individualized. The inclusion of these items on the APIB also suggests that intervention can be beneficial before the acquisition of particular behavioral states.

LENGTH AND FREQUENCY OF TREATMENT

Reports in the literature provide few definite guidelines for length and frequency of treatment. This suggests that treatment is generally individualized. The frequency of treatment ranges from once to several times per week, and each treatment session lasts for an indefinite length of time. None of the authors of these reports provide a basis for determining the optimal amount of treatment time.

Als (1981) reported that the examiner should pay careful attention to the infant's responses: "Underweight infants born at term tend to have more difficulty than average weight infants in attaining the calm, expansive, alert state required for interaction with the examiner."

During each treatment session the therapist should avoid overstimulating the infant. Overstimulation produces cues such as gagging, vomiting, crying, going to sleep, frowning, averting eyes, and changes in respiration. Tightly swaddling the infant helps calm a baby who is overstimulated, as does rocking, light patting, gentle talking, and allowing the infant to suck.

Anderson and Auster-Liebhaber (1984) have compiled a detailed description of treatment techniques for therapy in the NICU. Some of the techniques noted were positioning with more flexion, diapering with one leg extended and one flexed to encourage reciprocal patterns, swaddling, specific weight bearing, and rocking, stroking, and talking as long as the baby does not show stress. These techniques appear to be beneficial, but based on their observation and experience, they indicate that more research is necessary to establish the efficacy of particular treatment programs in the NICU.

HANDLING

Positioning the infant is difficult, as medical intervention supersedes and often seems to interfere with standard positioning procedures. The very flexed position maintained in utero is not copied in the NICU. Research in the

literature reviewed provides no data to confirm the best positions for VLBW infants. Refer to the article on positioning and position-induced deformities for a discussion of research on positioning.

Demilio (1983) compiled an annotated bibliography on the effects of chest physical therapy, the effects of positioning on respiration, and the effects of handling on neonates.

Although positioning and handling VLBW babies can be beneficial, therapists must recognize the potentially detrimental effects of handling these delicate infants. Tarby and Volpe (1982) observed that handling-induced motor activity can cause elevation in arterial blood pressure sufficient to produce intraventricular hemorrhage in an infant. Sweeney (1986) noted that the sensory stimulation during the neurological assessment of preterm neonates resulted in a significantly higher heart rate than did the same examination in term neonates.

Handling an infant in the NICU requires knowledge and skills that differ from working with infants in other environments. Therapists need to devise effective treatment programs. They must also teach parents of NICU infants to handle their children in ways that will promote bonding and attachment. The therapist who works with VLBW and other high-risk infants will benefit from reading the 1963 Thomas et al. study on temperament.

Typically therapists do not receive academic training in treating a "difficult" or "slow-to-warm-up" child. This may require extra sensitivity on the part of the therapist. In addition, the therapist may need to obtain additional services for a family that is experiencing difficulty in managing such a child. Als (1981) provided a very clear and concise explanation of the need to help mothers adapt to the special needs and characteristics of the VLBW or preterm infant:

"Mothers have a range of expectancies about infant behavior, and if their own child's behavior isn't within that range, the mother may need to make a conscious and deliberate accommodation to the child. Premies, difficult babies, babies with sensory defects and so on often demand that the environment expand what it 'normally' does, and the baby's little behavioral signals show just what works well for that particular child."

Less information is available about the expectations and reactions of fathers.

Outcome

For the purpose of this article, discussion of the outcome of preterm VLBW infants will be limited to neuromotor problems that can occur in these infants. Outcome in other areas of development is discussed elsewhere in this book.

Cerebral Palsy

Although cerebral palsy affects a minority of VLBW infants, it is one of the most serious problems affecting them. Cerebral palsy and muscle tone disturbances characteristic of this condition are not always well understood by professionals working with handicapped children. The following discussion may provide clarification of cerebral palsy and associated muscle disturbances in terms of their causes, incidence, and treatment.

The United Cerebral Palsy Association has provided the following definition and description of cerebral palsy:

"Cerebral Palsy is a group of conditions—not a disease—characterized by nerve and muscle dysfunction. Sometimes it shows itself by awkwardness of gait, loss of manual dexterity, or other motor problems. Other disabilities may be seizures; vision, hearing, speech and learning difficulties; or psychological and behavioral problems. Cerebral palsy is caused by damage to the part of the brain that controls and coordinates muscular action. Most often it occurs before, during, or immediately after birth because the supply of oxygen to the fetal or newborn brain is interrupted. This can happen if the mother is in poor health, undernourished, smokes or consumes alcohol excessively, or contracts certain viral infections early in pregnancy. Oxygen deprivation can also result from blood type incompatibility between parents, untreated jaundice of the newborn, adverse effects of medications, and other factors such as premature birth.

"In infants and young children, brain damage from an accident or child abuse can cause cerebral palsy; so can lead poisoning from swallowing bits of lead paint."

Cerebral palsy (CP) is not contagious nor is it a progressive condition. The other disabilities listed in the above definition may or may not be present but frequently accompany CP.

Physiology and topography are the determinants of CP. In 1956 Minear of the American Academy of Cerebral Palsy recognized eight types of CP according to physiological classification. These types include:

Spastic
Athetoid
1. Tension
2. Non-tension
3. Dystonic
4. Tremor

Rigid
Ataxic
Tremor
Atonic (rare)
Mixed
Unclassified

Most therapists and physicians use only the following four types to describe their patients: spastic, athetoid, ataxic, and rigid. According to Harris (1981) 95% of 3000 reported cases were included in these four types of CP. Mixed type is another common classification.

Cerebral palsy is topographically categorized. Monoplegia involves only one extremity (usually a lower extremity) and is rare. Hemiplegia involves the arm, leg, and face on one side of the body. Diplegia involves the entire body, but the lower extremities are more involved than the upper ones. Paraplegia involves the lower extremities only and is rare in CP. The most common paraplegic type is mild diplegia. Triplegia involves both lower extremities and one upper (and is rare). Quadriplegia involves the entire body, usually affecting all four extremities equally. This is not always true; asymmetrical findings are common. Sometimes the term "double hemiplegia" is used to denote involvement of all four limbs where one side is affected much more than the other.

According to Dorland's Medical Dictionary, "palsy" and "plegia" both mean paralysis. Although neither term is accurate, this terminology has remained since early descriptions by Winthrop Phelps in the 1930s. A better term is "paresis," which means slight or incomplete paralysis. It is often used instead of "plegia" to describe a child with a weakness on one side of the body. The condition is then a left or right hemiparesis rather than hemiplegia. Both methods of categorization are used to describe cerebral palsy. For example, spastic quadriplegia indicates both the physiology and the topography of the condition.

SPASTIC CP

The most common type of cerebral palsy is the spastic form. Harris (1981) reported that it accounts for from 40% to 75% of all cases. The most common clinical findings associated with the spastic type are increased resistance of muscles to passive stretch (or the clasp-knife phenomenon), clonus, positive Babinski, and increased deep tendon reflexes.

ATHETOID CP

Athetoid CP is the second most common type. Today it is usually associated with perinatal anoxia rather than hyperbilirubinemia as in the past. Infants are placed under bili-lights or are transfused earlier for jaundice than they used to be 20 or 30 years ago. However, direct causal associations between perinatal factors and CP are not well defined. Clinical findings associated with athetoid CP include fluctuating muscle tone, slow writhing movements, and variable deep tendon reflexes. These babies may initially present with extreme hypotonia, and athetoid movements may not be evident for a few years.

ATAXIC CP

Ataxic CP implies involvement of the cerebellum. Technically it is not "cerebral" palsy but is usually considered a type of CP. Characteristics include low muscle tone, intentional tremor (or action tremor, precipitated when

movement is initiated), overshooting the target when reaching for an object, wide-based staggering gait, and general lack of coordination.

RIGID CP

Rigid is often confused with spastic. Rigid CP involves increased resistance throughout the range of motion of a joint (the lead pipe phenomenon). Spastic CP involves increased resistance followed by a sudden relaxation (the clasp-knife phenomenon). (See the discussion of muscle tone below.) Deep tendon reflexes are increased, although extreme rigidity may prevent increased movement when the tendon reflexes are elicited.

MUSCLE TONE

One of the main characteristics of cerebral palsy is a disturbance of muscle tone. However, muscle tone disturbances often exist apart from CP. They affect a significant percentage of children enrolled in infant stimulation or early childhood intervention programs.

An intact central nervous system and muscle function are central to normal movement patterns and the orderly acquisition of motor milestones. Cerebral palsy affects the part of a child's central nervous system that controls movement. Bobath (1969) noted that abnormal patterns of movement and abnormal muscle tone characterize the motor deficit that occurs.

Muscle tone is the continuous mild contraction or tension of a muscle. It is dependent on the integrity of peripheral nerves and the central nervous system. Muscle tone is dependent also on the complex properties of muscles themselves, such as contractility, elasticity, and extensibility. A normal muscle at rest has resilience and will contract in response to passive longitudinal stretching. This response is the *stretch reflex*, which is essential in maintaining muscle tone. It provides a background of postural muscle tone necessary for voluntary movements.

Disorders of muscle tone may be the result of central nervous system impairment, peripheral nerve lesions, myoneural junction disorders, or myopathies. This brief dicussion covers only central nervous system problems that occur above the level of the spinal cord.

ASSESSMENT

In the *Neonatal Behavioral Assessment Scale*, T. Berry Brazelton defines muscle tone as the resistance of parts of the body to passive movement. Thus, body posture reflects muscle tone.

There is no specific clinical test for assessing muscle tone. Stolov (1966) reported that "in an assessment of muscle tone, the muscles are manipulated

by movement of the parts to which they are attached, and an attempt is made to appreciate the resistance (tension)." The overall impression of tone is subjective in nature. The assessment of an infant's muscle tone should include observations of the baby's spontaneous activity as well as its responses and reactions to movement and various positions and placements. Muscle tone varies with behavioral state. For example, a baby tends to have less tone while asleep and more tone while crying. Therefore, an observer can most accurately assess muscle tone when the baby is in an alert awake state.

Think of muscle tone as part of a continuum. Normal muscle tone may be increased or decreased and still be considered normal. Freedman (1979) noted that there also are differences in tone among newborns from different ethnic groups. In Freedman's study, black infants tended to exhibit more tone than Caucasian infants. Oriental and Native American infants exhibited less tone than Caucasian infants. Clinical practice generally supports these findings.

PATHOLOGIES OF MUSCLE TONE

Hypotonia, hypertonia, spasticity, and rigidity are the most common pathologies of muscle tone.

Hypotonia—Hypotonia generally refers to low muscle tone. It causes infants to appear "floppy." Infants with conditions such as Down syndrome and cerebral palsy often exhibit hypotonia. Hypotonic muscles feel soft and flabby and usually offer less resistance to passive movement. Either structural changes in the muscle itself (as in muscular dystrophy) or a decrease in the stretch reflex sensitivity can cause hypotonia. With central nervous system damage, such as cerebral palsy, the hypotonia is usually transitional. Intermittent spasms of increased muscle tone (as in athetoid cerebral palsy) may follow later, or spasticity may replace the hypotonia.

Hypotonic infants typically lie on their backs with their hips widely abducted, externally rotated, and flexed. Usually their knees are flexed and their upper extremities are flexed with the shoulders retracted (held back). When hypotonic infants are pulled up to sitting, their heads lag, their hand grasp is weak, and their elbows passively extend. Postural muscle tone appears to be weak and does not overcome gravity in these infants. In ventral suspension with the trunk supported, head, trunk, and limb control is poor. In severe cases, these infants may not be able to overcome gravity at all. Joint range of motion in hypotonic infants is generally increased throughout. They may not be able to bear weight on their legs when held in supported standing. These infants seem to "slide through the hands" as they are picked up. Head control is poor to absent in all positions, and deep tendon reflexes may be decreased or absent.

Although muscle strength is usually decreased in the presence of hypotonia, it is possible to have low tone with a considerable amount of strength. Flaccid

paralysis results with loss or impairment of motor function when there is no muscle tone and no deep tendon reflexes. This may be due to a central (brain or spinal cord) lesion or to a peripheral lesion.

Hypertonia—Hypertonic muscles (muscles with increased tone) are usually associated with spasticity and rigidity. Muscles may be hypertonic with or without hyper-reflexia and increased stretch reflexes. These are clinical signs of central nervous system damage. Other signs of damage are usually present also, such as a positive Babinski, ankle clonus, retention of primitive reflexes, and increased deep tendon reflexes. When a spastic muscle is passively moved rapidly through its range, there is an increased resistance to this movement, followed by a sudden relaxation. This is an abnormal stretch reflex known as the clasp-knife phenomenon. In rigidity, severe resistance to passive movement is felt throughout the range due to sustained contraction of agonists and antagonists (muscles on both sides of the joint).

Spasticity and Rigidity—Spasticity and rigidity are often more debilitating than the underlying weakness of a particular limb or muscle group. Frequently they account for abnormal movement patterns seen in cerebral palsy, which are in addition to those caused by a lack of normal postural reflexes. One of the major goals of Bobath's (1969) NeuroDevelopmental Treatment is to reduce abnormal muscle tone in patients who have cerebral palsy. This is reportedly accomplished through a number of handling and facilitation techniques that are taught to the primary caregiver by therapists trained in this therapeutic treatment technique.

When spasticity is present over a period of time, the body assumes certain classic stereotyped postures. Muscles become shortened, resulting in contractures, and orthopedic problems develop. Spasticity will be present in the extensor muscle groups as well as the flexor muscle groups. The degree of severity of spasticity is dependent upon a number of factors, including the location and severity of the lesion and the position of the patient.

Cerebral palsy may not always be obvious to parents.

The excellent drawings on pages 36-74 of *Handling the Young Cerebral Palsied Child at Home* by Nancie R. Finnie, FCSP, demonstrate typical postures assumed by children with cerebral palsy. This classic book continues to be a necessary resource for the families of these children and for the personnel involved in intervention programs.

Intervention after Discharge from the NICU

In an introduction to *Infants at Risk. Assessment and Intervention: An Update for Health-Care Professionals and Parents*, T. Berry Brazelton reports that practicing physicians tend to postpone referral of developmentally impaired infants to intervention programs until a mean age of 14 months. According to the United Cerebral Palsy Foundation, infants who arrive at intervention programs by 4 months of age usually have been referred by their parents rather than by their physicians. There are a number of reasons for this discrepancy. Physicians may not be comfortable with making an early diagnosis that may later be incorrect, and they may not want to give parents information that is difficult to accept. Parents tend to be attuned to problems in their infants at a relatively early age and believe that they and their children are most likely to be helped through early intervention. (Brazelton, 1982; Amiel-Tison, 1985.) When parents can channel their energy into positive action with a special needs or high-risk infant, both parents and children benefit. Parents often report more frustration when they lack confirmation that something is wrong than when they receive bad news about their child's prognosis.

Taft (1981) pointed out that intervention programs offer benefits, such as progress in the parents' ability to adapt to their infant's handicap. The parent-child relationship often improves, and the child experiences heightened motivation and self-esteem. Intervention programs may be helpful in some respects for families and children, but there is no well designed and controlled research that indicates that early intervention changes the long-term course of CP. St. James-Roberts (1979) suggested that perhaps other pathways can take over for damaged ones; the earlier the therapy begins, the greater the chance for change. On the other hand, Amiel-Tison (1985) noted that physical therapy does not act on the brain itself but on motor function by maintaining muscles and joints, by reducing the effects of transient or permanent muscle tone imbalance, and by teaching the child to use remaining physical abilities in the most efficient way.

Laurence Taft, M.D., (1981) has observed that the motor abnormalities of infants with cerebral palsy are not likely to be significantly reduced through intervention. Despite this, Taft views intervention programs as beneficial for handicapped children and their families for the following reasons:

- Better parent-child relationships are established.

- The child may be more motivated to try new motor tasks.
- There is less "shopping" by parents for professionals or agencies to repeatedly reevaluate the child.
- There is a quicker adaptation to the child's handicap.
- The child appears happier.

Neurodevelopmental treatment proponents advocate handling techniques that may help parents feel more comfortable with, for example, a spastic child. However, physical therapists and occupational therapists put a great deal of emphasis on improving motor control for such children. This may not be the correct approach in a child whose motor skills are severely impaired. The parents, therapists, and even the child may put too much emphasis on motor function at the expense of other, possibly more important, areas of development. Cognitive, language, and social skills that can be improved may have more effect on the individual's adjustment than working on motor skills that will never be normal. Use of technology such as powered wheelchairs and communication devices are much more likely to significantly improve life skills than will exercises for those with severe motor impairment. If an intervention program has its focus balanced among all areas of development and incorporates the expertise of several disciplines, this happens less often.

Physicians and others have criticized therapists for denying children with CP the use of abnormal reflexes to achieve small goals. It is difficult to tell parents whose children have fed themselves for the first time by using an asymmetrical tonic neck reflex that this is wrong. Als points out, "Somehow there's the notion that only motor output matters. We need to see social and emotional behavior as an equally important part of the integrated capacity of the nervous system."

At the Meeting Street School, the focus of intervention is on emphasizing positive aspects of existing sensory motor strengths of the child rather than remediation of deficits. The following guidelines for interventionists are from this school, as reported by Denhoff (1980).

- Do not interfere with the natural timetable of skill emergence.
- Initiate enrichment activities at the baby's level and on the baby's terms.
- The order of intervention is social-emotional, communication, perceptual-motor, motor.
- Sensory awareness precedes motor output.
- Parent grief reactions are often camouflaged. Understand, help, and reassure, but be honest and realistic.

Physicians must determine whether a child's neuromotor abnormalities will be transient or will remain as indications of cerebral palsy (CP). Hagberg et al. (1982), Drillien (1972), Nelson and Ellenberg (1982), and others have shown that most of the perinatal cases of CP take a mild form. Neuromotor

abnormalities that may appear as spastic diplegia or hemiplegia may actually disappear some time late in the first year of life.

Is it possible to predict the outcome for a particular child from the assessment of risk factors determined by neurological examination or developmental testing? There is considerable discussion on this subject. Therapists need to be able to pull together certain characteristics common to VLBW or other high-risk infants to aid in predicting later outcome. However, there is still no formula for predicting outcome. Some infants with extremely rocky beginnings do well later, while others do poorly. As Siegel (1985) observed: "Developmental outcome is not determined by a single factor; a variety of biological and social factors are important for the prediction of difficulty."

Barnard (1981) noted that parental education and socioeconomic level are very important predictors of outcome. In addition, caring for a preterm infant seems to take a toll on the parents toward the end of the baby's first year. By this time, the infant is becoming more responsive, with sleeping and feeding habits the parents can accept. However, the parents may have expended so much emotional and physical energy already that they experience "burnout."

A national collaborative study, the Infant Health and Development Program, is a major program to assess the efficacy of early health and developmental intervention with healthy low birth weight neonates. This multimillion-dollar, eight-site study is directed by Dr. Gross at Stanford University. Results of the randomized trial of developmental intervention, the first results of which were available in 1989, should have major implications for the future of early intervention for these children.

Follow-Up of the Preterm Infant

One way to approach the longitudinal assessment of motor and neurologic function of VLBW infants is by looking at their characteristics at significant age periods. These would include the preterm period, preterm but approaching 40 weeks gestation, the first three to four months, the end of the first year, from 12 months to school age, and the school age period.

Prechtl (1981) suggested assessing "optimality" instead of risk. Because it is not possible to predict outcome by assessing Apgar scores, low birth weight, intraventricular hemorrhage, hypoxia, or other such criteria, he suggested the alternative, which is documented extensively: Infants who are in good shape at birth almost always do well.

Investigators have addressed the problem of consistency when assessing developmental and neurological dysfunction. Consistency in prediction is higher for motor outcome than for cognitive. Infants whose motor scores on

the Bayley Scales of Infant Development (BSID) were normal in the first few months of life tended to remain so through 40 months. If a change in motor development did occur, it was most often in a positive direction. Aylward et al. (1985) postulated that this stability may reflect a mild environmental influence on motor development, and any improvement may reflect the plasticity and compensatory abilities of the child's central nervous system. This consistency does not hold for Bayley Mental Scores and subsequent intellectual outcome.

THE PRETERM PERIOD

The usefulness of a neurologic examination is questionable because it is difficult to establish gestational age. (Amiel-Tison, 1985; Dubowitz, 1985.) The majority of infants who show abnormal motor or neurologic functioning at birth and soon after usually improve. (Aylward et al., 1985; Amiel-Tison, 1985; Prechtl, 1981.) Dubowitz and Dubowitz (1981) and Amiel-Tison (1985) reported that some neurologists recognize intraventricular hemorrhage (IVH) by clinical signs. On the other hand, Stewart et al. (1983) indicated that this is not possible. In any case, the presence of IVH is not well correlated to outcome. The associated leukomalacias (ischemic white matter) are more predictable, yet the use of ultrasound may not show leukomalacias for several weeks posthemorrhage. Menkes (1980) reported that spastic hemiparesis is associated with cystic lesions following IVH; therefore the presence of cystic lesions in the brain may alert one to watch for later development of spasticity.

PRETERM APPROACHING 40 WEEKS

Amiel-Tison (1985) maintained that an examiner can perform a complete neurological evaluation if the infant has achieved good respiratory and nutritional status. The best perinatal predictor of poor outcome is the presence of ventricular enlargement documented by ultrasonography. During this period, physicians can identify infants with hydrocephaly requiring shunts. The developmental outcomes of these infants vary. According to Lipscomb et al. (1983), the prognosis tends to be better than previously noted, but when infants have large hemorrhages into brain tissue, they may still show some neurodevelopmental deviance.

FIRST THREE TO FOUR MONTHS

According to Amiel-Tison, this period represents the recovery phase and extends from 40 weeks conceptional age to 3 or 4 months corrected age. Infants at this age are usually at home, and it is a time when parents often experience extreme anxiety about their child's future. These parents can be offered some reassurance, because abnormalities in motor and behavioral areas observed during this period of time are usually transient and disappear as the year progresses. Marked hypertonicity in the form of increased flexor tone may be present in the child's limbs.

Ellenberg and Nelson (1981) found that children in this age period manifest several characteristics associated with later onset of CP:

- Increased tone in the neck extensors and trunk (increases in extremity tone was not predictive).
- Jitteriness and tremulousness.
- Inability to sit with head up using arms for support.
- Inability to assume the prone-on-elbows position.
- Lack of interest in a mirror image.

Asymmetrical movements were not statistically significant as predictors of later onset of CP. Hypertonus in black infants is not as predictive as it is in white infants.

In one follow-up study of 300 LBW and VLBW infants with transient dystonia, Drillien (1972) found that 6% had CP, 23% had suggestive signs but were normal at a year, 17% had equivocal signs but were normal at a year, and 54% showed no signs and were neurologically normal. The chief characteristics of this study group were abnormalities of movement and posture, reflex abnormalities, and delayed development. In 60% of the infants, these abnormalities disappeared. In 20% of the cases studied, the children appeared to have no signs of cerebral palsy but were later diagnosed as having mild diplegia or ataxia with hypotonia.

McDonald (1963) noted a correlation between spastic diplegia and preterm birth. Since that time, other studies by Lubchenco et al. (1974) and Davies and Tizard (1975) have reported a decrease in spastic diplegia. The association between preterm birth and cerebral palsy is an ongoing concern of neonatologists, and the strength of association varies with study techniques and definitions of CP.

Goldberg (1974) cited a study in which more than half the infants with neonatal hyperbilirubinemia displayed hypotonia and motor delay. "The hypotonic stage may last from 6 weeks to 17 or more months. Generally, the longer the hypotonic period lasts, the more severely disabled the child," reported Steele (1985). Amiel-Tison (1985) indicated that "tone imbalance is a worrisome pattern within the first three months, when excessive hypotonicity in the neck flexors and upper extremities (no resistance to the scarf maneuver) is contrasting with hypertonicity in the lower limbs." She considered imbalance of the neck flexors and extensors to be a significant abnormality in VLBW infants. VLBW infants with this imbalance did not exhibit good head control at the expected 2-3 months corrected age.

Is it possible to differentiate those infants whose deviations will be transient from those whose eventual outcome is likely to be abnormal? Amiel-Tison (1985) believes it is possible to predict normal outcome by the use of the following procedures:

- When the reaction of lateral abduction of the lower limb is present, the absence of cerebral palsy in the lower limbs may be affirmed. Similarly, when lateral straightening of the trunk with active support by the arms is observed, the absence of gross motor impairment may be ascertained.
- If, however, the reverse is found, this does not mean the infant will have CP. She indicated that further work is needed in this area of evaluation.

To summarize the first three-month period, Amiel-Tison concluded that transient muscle tone abnormalities are common. There may also be disturbances in behavioral state and increased excitability. Two courses are possible. One is that the child will be normal, perhaps with the possibility of later learning problems in school, and the other is that the child's abnormal signs increase so that a diagnosis of CP can be made.

END OF THE FIRST YEAR

By 8 to 10 months, Fitzhardinge (1980) noted, major defects are easily recognizable. The diagnosis of severe CP can be made and transient abnormalities may still persist. Amiel-Tison described the difference between those abnormalities that indicate CP and those that are likely to be transient.

The abnormalities indicating CP are:
- Poor active trunk muscle tone.
- Strong righting reaction with scissoring.
- No opening of the popliteal angle (tight hamstrings).
- Tonic stretch reflex in the triceps.

Transient abnormalities include:
- Changing muscle tone (active and passive).
- Phasic stretch reflex.
- Normal lateral trunk reactivity with no scissoring.

Ellison et al. (1983) found that neurologic examination from 10 to 15 months can be highly reliable in detecting long-term abnormalities. The Aylward et al. (1985) study also supports this.

TWELVE MONTHS TO SCHOOL AGE

By the age of 12 months, most severe motor problems have been identified. During this period concern shifts from assessment and treatment of motor problems to the child's cognitive and language function.

The Bayley Scales of Infant Development Motor Scale and other instruments are the usual ways of testing motor milestones in the preschool years. The standard neurologic assessment is also done. Among the tests that assess quality of movement there is no standardization, which such instruments need

in order to produce valid results. The tests can indicate a change, but they do not predict the significance of the change.

SCHOOL AGE

There may be a relationship between the transient abnormalities seen in the first year and long-term neurologic problems, but researchers have not defined it. However, it is important to recognize these abnormalities, as they may identify children at risk for minimal cerebral dysfunction and learning problems in school. (Drillien, 1972; Rubin and Balow, 1980; Drillien et al., 1980.) Minimal cerebral dysfunction is defined as hyperactive behavior, soft neurologic signs, and perceptual motor problems. This type of dysfunction seems to develop more often in the larger preterm infant than in the VLBW infant. It is, of course, not limited to the preterm infant.

Ellison et al. (1985), Gilberg and Rasmussen (1982), and Hunt et al. (1982) have demonstrated the relationship of early transient abnormalities to problems that show up later, such as poor fine-motor skills, visual-motor integration problems, and decreased fine-motor control. However, use caution when making a prognosis for an infant who shows transient abnormalities. Only about a third of the children in the above studies exhibited problems later.

Follow-Up Studies

A summary of nine follow-up studies of a total of 859 infants whose birth weight was 1500 grams or less reveals that 10.6% of these infants have significant cerebral palsy. The age at assessment was about 2 years. One study from Toronto (Bennett Britton et al., 1981) reported no intact surviviors with birth weights below 700 grams, and 14% of those whose birth weights were between 700 and 800 grams had a major handicap.

Definition of Terms

Abduction: Away from the middle of the body.

Adduction: Toward the middle of the body.

Asymmetrical Tonic-Neck Reflex (ATNR): Brainstem level reflex that is normal for about the first four months of life. Often seen in children with cerebral palsy. Test position—supine. Head is rotated to the right. Positive response—face limbs extend, skull limbs flex.

Babinski Reflex: Positive response—extension of great toe with splaying of other toes upon stimulation to lateral border of sole of foot. Sign of central nervous system impairment in children of walking age.

Caudocephalic: From the tail to the head, such as development of leg muscle tone preceding muscle tone in the arms.

Cephalocaudal: From the head to the tail.

Clonus: Series of abnormal (after 6 months of age) reflex movements caused by a quick stretch to the calf muscle group (heelcord). The foot exhibits rapid oscillations called "beats."

Cortical Thumb: Sign of central nervous system impairment. The thumb is held tightly into the palm, which stimulates the hand grasp to close the fingers around it.

Deep Tendon Reflex (DTR): Normal phasic response of a muscle tendon being stimulated by striking it. Most commonly assessed DTRs are patellar (knee), ankle, biceps, and triceps.

Dorsiflexion: Usually, movement of the foot toward the shin.

Dyskinesia: Impairment of power of voluntary movements resulting in incomplete movements.

Dystonia: Disordered muscle tone. The joint moved remains in a distorted position for a short period of time.

Extension: Movement of a joint into a straightened position.

External Rotation: Rotary outward movement of a joint, usually the hip or shoulder joint.

Flexion: Movement of a joint into a bent or flexed position.

Internal Rotation: Rotary, inward movement of a joint, usually the hip or shoulder joint.

Lanugo: A coat of downy hair, especially when covering a fetus or newborn.

Minimal Cerebral Dysfunction: Also called Minimal Brain Dysfunction (MBD), Minimal Brain Damage or Injury, or Minimal Cerebral Palsy-Syndrome. It refers to a child of average, near-average, or above-average intelligence with learning or behavioral disabilities characterized by perceptual problems, perceptual-motor problems, and language, memory and/or control-of-impulse problems.

Neurodevelopmental Treatment (NDT, Bobath): Cerebral palsy treatment techniques utilized to normalize muscle tone, inhibit abnormal postural reflexes, and facilitate more normal movement patterns. Developed by Karel and Berta Bobath.

Nociceptive: Noxious or painful.

Opisthotonos: Severe hyperextension of the neck and spine that causes backward bowing of the body. Usually a sign of severe spasticity.

Plantarflex: Extension or pushing away of the foot from the shin, as in tip-toeing.

Popliteal Angle: Angle at the knee formed by the calf and the thigh.

Praxis (Motor Planning): Cortical function of learned movement.

Primitive Reflexes: Those reflexes seen in the newborn period that are integrated by higher centers of the brain in the first months of life. Persistence indicates central nervous system damage. Examples include Moro, hand grasp, and crossed extension.

Soft Neurological Signs (Minor Neurological Signs): Often associated with minimal brain dysfunction. Examples are incoordination, inability to tandem walk, difficulty with balance, associated (overflow) movements, slight tremor, increased deep tendon reflexes, or difficulty with performing rapidly alternating movements (dysdiadochokinesis).

Static Congenital Encephalopathy: Term usually used to mean a non-progressive brain dysfunction. Often used to describe cerebral palsy, mental retardation, or developmental delay.

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Early Childhood Intervention

by Allan K. Bird, Ph.D., and Nancy M. Bray, Ed.D.

Beliefs and knowledge about the influence of a child's earliest years on later development have contributed to the establishment and expansion of early intervention programs in this country. Hunt (1961) and Bloom (1964) were among the first professionals to advocate early intervention. They believed in the necessity of facilitating high-quality early "experiences in order to improve the developmental outcome of children." Throughout the short history of analyzing the available developmental outcome data, the findings—and conventional wisdom—have suggested that "the earlier we initiate appropriate intervention programs, the greater the child's chances of developing his or her potential to the fullest" (Karnes, 1982).

Since the 1960s, federal legislation and support has spurred dramatic increases in the number of programs responding to the developmental needs of infants and toddlers and their families. In the first years of the early intervention movement, federal funding provided for the development of services to meet the needs of economically disadvantaged preschool children. Later programs focused on those children with handicaps as well. In the 1960s, the Handicapped Children's Early Education Program awarded grants to public and private agencies to develop exemplary and replicable programs for handicapped preschoolers. In 1974, Public Law 93-380 mandated the provision of programs for unserved handicapped children, including those of preschool age. In 1975 Public Law 94-142 provided incentive grants to develop preschool programs for the handicapped. The most recent legislation, Public Law 99-457 of 1986, reauthorized educational programs for those children with special needs and specifically addressed particular programs for infants and toddlers and their families.

As a result of Public Law 99-457, federal monies have provided significant increases in funding levels as an impetus to states to expand preschool programs. Another key component of this law is the establishment of a comprehensive interagency program to provide early intervention between

birth and 2 years of age for children with handicaps. The law demands documentation of the services, procedures, and timelines for the completion of each child's intervention. The law also requires each state to establish an Interagency Coordinating Council consisting of members who are appointed by the governor. In addition to the public and private service-providers, parents of handicapped infants and toddlers must be included among each council's 15 members.

Who Should Receive Intervention?

THE CHILD

Intervention programs serve children with various types of developmental problems. Some of the first projects served children who received inadequate environmental experiences because of their socioeconomic circumstances. Later programs served children who had manifested developmental disorders such as sensory or orthopedic handicaps or mental retardation. The enrollment of developmentally delayed children was emphasized, although the extent and magnitude of the delays necessary to qualify vary by program or by state guidelines. At present, there appears to be an emphasis on providing services to high-risk groups. For those children considered vulnerable to problems that may subsequently develop, the risk factors may be biological or cultural. Biological problems appear in babies who were very low birth weight, small for gestational age, or ventilated, or who experienced other conditions that may be correlated with later difficulties. Other risk groups are children of parents who are adolescents or cognitively impaired. Programs for at-risk children differ according to the population they serve, and no "usual standard" exists to guide the identification of this group of children.

Public Law 99-457 provides for services to be offered to those children who already have experienced developmental delays or who have a high probability of later manifesting developmental delay as a result of a diagnosed mental or physical condition. Eligibility is determined through the "administration of appropriate diagnostic evaluation instruments," which document a child's delay in one or more of the following areas of development:

- Cognitive
- Physical
- Speech and language
- Psychosocial
- Self-help

Each state may prescribe the specifics of the eligibility criteria. The state determines if and by what guidelines high-risk children are to be served.

THE FAMILY

A key feature of Public Law 99-457 is the increased emphasis on the role of the family in the child's intervention program. Bailey and Simeonsson (1984) noted that early intervention programs have typically included family members in various ways in the assessment and intervention process, but their role has expanded over the years.

In the early years of intervention programs, parent involvement meant including them in the planning process. For example, the parents provided information about the child's abilities in the home setting and helped determine what was appropriate for their child in an educational environment. The literature has not always delineated the specifics of parent involvement. Gilliam and Coleman (1981) have suggested that in many programs when parents are involved, they are not likely to contribute significantly. Further, as Goldstein and Turnbull (1982) noted, when parents do participate, it is primarily through giving and receiving information. They rarely function as active planners or implementers. Whether or not the parents assume as active a role as the professionals concerned might desire, the parents have the right to be involved. Most parents have reported satisfaction with their role on the planning team no matter what their level of participation.

More recently, parents have been expected to assume greater responsibility as direct service providers to their children. Research findings have demonstrated that family members can be effective teachers (Filler and Kasair, 1981; Weitz, 1981; Adubato et al., 1981; Cunningham et al., 1982). The responsibilities of early childhood interventionists have expanded from instructional management of the child to training the parents and other caregivers to provide the child with indirect developmental stimulation. This training occurs through child-centered one-on-one methods (often during home visits) as well as through group classes. Interestingly, Winton and Turnbull (1981) found that despite enthusiasm on the part of the professionals involved, many parents have preferred not to assume this role, but instead have chosen to leave intervention to the specialist.

Lately a new view of parental involvement has been promoted in which the whole family, not merely the child, becomes the target for intervention efforts. It is generally agreed that an infant with developmental problems presents a myriad of challenges for the family, but it is not entirely clear what the role of intervention should be in this situation. Should a program require that a parent receive training before accepting the child? What are the differences in services provided by the childhood interventionist and the mental health professional in assisting a family? What should happen to a child if a parent views the family's needs from a different perspective from that of the professional involved in the problem? These are typical issues that must be addressed during the determination of what course to take.

Types of Intervention Programs

Intervention programs vary considerably. They generally differ in areas such as the following: the setting in which they are offered, the philosophy of intervention that they espouse, and the staffing patterns of the program.

SETTING

- *Home-Based*—Many of the programs designed for younger children involve activities in the home. The teacher or interventionist meets with the child and the parent or caretaker to furnish ideas and tasks that encourage the child's development.
- *Center-Based*—Children come together in a group and work with the interventionist. In addition, the program sets aside time for the parents to observe the program or to interact directly with the children.
- *Specialized vs. Generalized Programs*—Some programs elect to serve only certain populations, such as children who are developmentally delayed. Other programs offer their services only to a specific subgroup, such as children who are culturally disadvantaged, have language disorders, or are hearing- or vision-impaired. Other programs serve a heterogeneous population with a broad array of difficulties.

PROGRAM STRATEGIES

A few of the early programs adopted a single theoretical approach to intervention, but today eclectic solutions prevail. When considering whether a program is suitable for a particular child, investigate which approach that program stresses. Some of the factors to consider are as follows:

> **Is the program based on a developmental philosophy? Does it stress prescriptive teaching? Does it use remedial logic?**

Developmental programs place their emphasis on managing the environment to keep the learning situation as natural as possible. In this setting, the child learns by using sequences, but these programs tend to be process oriented. They often do not work towards developmental milestones. For example, if the goal of the developmental program is to learn to imitate, it doesn't matter what the child is imitating; if the goal is to look for hidden objects as a way to establish object permanence, it doesn't matter what the object is.

Prescriptive methods stress teaching developmental skills. Generally, some type of developmental skills checklist is employed. For example, the child may be taught to stack blocks. In the developmental approach, this might be one of the skills used to teach spatial relations. Or the "b" sound might be taught to a child. If this specific skill were used in the developmental program, it might be an example of imitation.

Remedial logic programs may not follow developmental sequences. Proponents of this approach identify certain critical skills necessary for functioning in a daily environment. These then become the target for instruction. They teach those rather than earlier skills, which they may not see as essential to daily functioning. For example, it may be decided to teach the child to perform 1-1 correspondence, though developmentally there may be earlier skills, such as counting by rote. In a sheltered workshop environment, 1-1 correspondence could be helpful, while counting by rote probably would serve no useful purpose. Reading words rather than memorizing the alphabet may be another example. In teaching reading, rhyming and some other skills might be omitted, with the stress being placed on comprehension based on sight recognition.

Is the program behavioral or functional?

Behavioral programs tend to be teacher-directed, with emphasis on direct instruction and rewards for appropriate behavior. Functional programs tend to deemphasize direct instruction, focusing instead on behaviors that the children instigate. The teachers' role is to encourage the children to initiate behaviors rather than the teachers setting goals themselves.

No evidence exists at this time to suggest that any one specific technique is substantially better than any of the others.

PROGRAM SPECIALISTS

The idea of providing infants and toddlers with services has captured the interest of specialists from a variety of disciplines. Professionals with varied training have traditionally shared their expertise in providing services to older children with disabilities, but the necessity for interdisciplinary collaborative efforts is underscored while helping children during the preschool years.

The age and the perceived needs of the child and the setting in which the services are provided help determine the composition of the service team. For example, a hospital-based team serving newborns may consist primarily of nurses, social workers, and a professional (such as an O.T. or P.T.) to work with the child's positioning and motor development; a community-based center serving children of 3 years of age may have educators, speech pathologists, and others. Further, certain disciplines may provide the core members of a particular team because of the needs of the children in that program. The team may then seek contacts or consultation from other disciplines for children in their program who have unique problems. Some of the specialists frequently involved with teams are:

Audiologists
Early Intervention Specialists (Educators)
Nurses
Nutritionists

Occupational Therapists
Physical Therapists
Psychologists
Speech-Language Pathologists
Social Workers

In many early intervention programs, the primary discipline affiliations may not reflect the roles the various professionals serve on the team. For example, handicapped children often have feeding difficulties. The "feeding specialist" on the team might be a speech pathologist, an occupational therapist, or an early intervention specialist; each of these disciplines may be trained in this area. Consultation for behavioral difficulties may fall within the scope of several members of the staff. In many programs, transdisciplinary training occurs, and professionals from different disciplines learn how to carry out varied functions. While social work and psychology are typically the disciplines that provide direct services to families, the case manager (in agencies with staff case managers) may be the professional most involved with the family. The case manager will consult with other professionals trained in family services as needed.

The Effectiveness of Early Intervention

The efficacy of early intervention programs interests professionals in clinical service to children, as well as administrators and funding agents. General findings summarized from the literature by Mullen and Rogers (1981) include the following:

A healthy baby is the ultimate goal.

- Early intervention has positive effects on the development of both children who are at risk and those who have handicaps. These gains are often sustained for years.
- The impact of a program does not always affect specific academic areas, but generally the academic and social performance of program participants demonstrates positive results.
- Intervention that includes the parents significantly facilitates the development of the child. The short-term outcomes with young children are not significantly better than when parents are not involved, but the long-term results improve.
- Infants ususally benefit more from home-based programs that utilize parent involvement; toddlers advance with group-oriented programs that maintain parent involvement; and preschoolers often profit from programs that are group center-based.
- The long-term cost of early intervention amounts to less than the expenses of intervention that begins later.

Other investigators have examined different variables associated with program success, such as the following:

- Bronfenbrenner (1974) has suggested that the earlier a child enters a program, the more positive the outcome.
- While most of the programs have not provided specific details regarding the type and extent of parent involvement, it is clear that parental interest is important to the child's outcome.
- Gray and Klaus (1970) have suggested that duration of participation is a factor in outcome. The children who remain in a program for a substantial period of time do better than those who do not.
- As in almost any type of intervention situation, Lazar and Darlington (1978) conclude that the amount of time spent with the teacher on task is an important variable in the child's progress.

Most reports that look at early intervention suggest positive outcomes. White et al. (1984), after reviewing the 21 programs approved by the Joint Dissemination Review panel, pointed out many of the important contributions of these programs to early intervention. Nonetheless, the study produced the following statement about efficacy:

"Unfortunately the methodological weakness of the research conducted by all JDRP-approved early intervention projects is so serious that the resulting efficacy data are of questionable value."

White and his colleagues described procedures that would more adequately assess the efficacy of intervention programs. It may not be possible, however, to use scientific methodology to study the variables that are considered clinically important.

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The Legislative Arena

by Nancy Young, R. N.

Networking has become a popular instrument for combining the efforts of different groups that have related causes. While an individual can still have an impact on any given issue or cause, a combination of energies can offer a synergistic force that may have a greater effect in a shorter time frame. Providers of health care have begun to utilize networking to reach additional groups that have an awareness of their vested interest in the delivery of health-related services. In some cases, they also communicate with those who have not arrived at an acceptance of the importance of prevention and follow-up in reducing long-term disabilities.

Those of us in the perinatal health arena have definitely neglected our potential allies in the state legislatures and in Congress. These lawmakers have control of both power and money. Their decisions profoundly affect the outcome of parents and children throughout the United States. We must educate them regarding our daily struggles as well as our success stories so they can join us as advocates for better health care. Many of us lament the problems in delivery and access, as well as a lack of services and assistance. But how many of us have taken the time and effort to address these issues in a manner that will have a significant impact? We can accomplish much, both individually and through affiliation with organizations that are committed to taking an active advocacy role.

Following are some suggestions for becoming a political force in your own community on behalf of parents and children:

- Know who your legislators are. Call the League of Women Voters for a list.
- Make appointments for personal visits with some of your legislators, preferably between sessions, when they have more time. Such meetings can be quite pleasant and productive.
- Write your legislators a personal letter periodically to relate events, struggles, or case studies from your district.

- Invite your legislators to visit your facility and to observe any special events that you plan throughout the year.
- Become a member of organizations involved in a coalition working on behalf of perinatal issues, such as the National Perinatal Association.
- Invite your legislators to speak at professional meetings and other gatherings to educate them about your group as well as to hear their viewpoints on perinatal issues.
- Be available to testify at local, state, or federal hearings about health care.
- Use the media to bring your issue to the public's attention.

Statistical information carries a great deal of weight if it is accurate. Define your region (city, county, state) and research information such as the following:

- Number of babies born
- Percentage of babies who die by age 1 year
- Percentage of low birth weight (LBW) babies
- Percentage of LBW babies born to women without prenatal care
- Percentage of birth defects
- Number of institutions for the mentally retarded

The costs of LBW babies or children with developmental disabilities are also pertinent. In fact, the list could go on indefinitely. By obtaining accurate statistics of a defined concern and suggesting to your legislator possible solutions, you can have more impact on the legislative process. You have to determine what changes can be most effective to improve health care for your population and how best to implement these changes.

Summary

by Caryl J. Semmler, Ph.D., O.T.R.

Very low birth weight (VLBW) babies present a significant mortality and morbidity risk when compared with full birth weight (FBW) newborns. The consequences of VLBW are an increase in special problems that are rarely, or at least less often, seen in FBW newborns.

Information summarized from the preceding articles delineates numerous problems in VLBW babies. Some of the medical complications important to follow-up care include the following:

- Intracranial hemorrhage occurs in approximately one-third to one-half of VLBW babies, with the highest incidence in the smallest infants and those who are ventilated. The small amount of published data on outcome suggests that over half the babies with Grade IV hemorrhages die, and approximately 80% of the survivors have neurologic abnormalities. The severe neurological abnormalities may be less severe, but still significant, as the children progress through elementary school age. Babies with Grades I and II hemorrhages may not differ significantly in developmental outcome from VLBW babies without hemorrhages.
- Post-hemorrhagic hydrocephalus occurs in 25-80% of survivors of intracranial hemorrhage. It may not be detectable by clinical parameters such as head growth and bulging fontanel until days or weeks after significant ventricular dilatation. Usually follow-up ultrasound head studies are needed.
- Secondary craniosynostosis may develop during the first year of life as a result of brain atrophy. This is not surgically treated, and is often accompanied by developmental delays.
- Bronchopulmonary dysplasia occurs in about 3.7% of ventilated infants with respiratory distress syndrome. Mortality occurs in about 25-39% of these infants during the first seven months of life. Rehospitalization for lower respiratory infection is high, especially during the first year after newborn nursery discharge.

- Hypothyroxinemia occurs in a higher percentage of VLBW than FBW babies.
- Retinopathy of prematurity (ROP) results in no functional vision in about 5-11% of babies weighing less than 1000 grams at birth. Mild grades of ROP may spontaneously resolve.
- Apnea and bradycardia may occur when a VLBW infant is placed in an ordinary car seat.

VLBW babies have been identified as a group that runs a high risk for developmental delay. The evidence is that most VLBW infants have normal developmental quotients, but the incidence of significant mental retardation is greater in VLBW infants than in FBW babies. The incidence of reading problems in children of low birth weight with normal IQs appears greater than in full birth weight children with normal IQs.

- Babies who manifest delays when tested must still qualify for infant development programs. Qualifying for services is based upon certain test scores or medical problems according to state guidelines for special education and/or individual agency criteria. These criteria often vary from state to state.
- Biologic and medical factors appear to correlate with developmental problems in infancy, but environmental factors appear more highly correlated with developmental status at older ages.
- As a group, LBW babies tend eventually to show more delay in perceptual-motor than verbal areas.
- VLBW infants have a high incidence of transient neurological abnormalities such as abnormal reflexes or muscle tone. Approximately 40-60% of neurologic abnormalities noted during the first four months of life will resolve to normal limits.
- Reported incidence of cerebral palsy in VLBW infants is approximately 10%, although this figure varies according to definition.
- Most severe motor impairments (cerebral palsy) of VLBW babies can be detected by about 8 to 12 months of age, although milder deficits or athetoid cerebral palsy may not be evident for several years.
- The position of a baby in its bed can significantly affect multiple body functions. The prone position appears to be preferable for increased oxygenation in neonates. Prone with the head elevated about 30 degrees is preferable for babies with gastroesophageal reflux.
- Biomechanical forces exerted on the hypotonic VLBW baby during positioning can mold the bony and soft tissues, resulting in a flattened, elongated head and externally rotated, abducted extremities. Appropriate positioning may help decrease these deformities.

Nutrition and feeding of VLBW babies is a major concern during infancy. Accurate measurement of height, weight, and head circumference is very important to total nutritional care. Measurements of these infants must be corrected for prematurity.

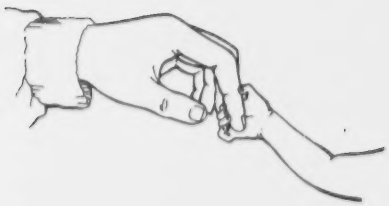
- VLBW babies may require special formulas because of an immature gastrointestinal tract, medical problems such as bronchopulmonary dysplasia, or necrotizing entercolitis.
- Nasogastric or gastrostomy tube feedings may be required to maintain adequate weight gain after hospital discharge in a small percentage of VLBW babies.
- VLBW babies with oral-tracheal intubation may have a palatal groove or dental anomalies resulting from the pressure from the tube.

The effects of a VLBW baby upon the family may be substantial both emotionally and financially.

- The Neonatal Intensive Care Unit is a cultural scene that may differ significantly from any other environment that the family has experienced. Families of different cultures may deal with the system very differently.
- Parents of VLBW babies go through the same feelings of shock, denial, sadness, anger, and resolution that are experienced with losses such as the death of a relative. These are normal responses to an abnormal situation. Some parents will display maladaptive responses.
- VLBW neonates make poor interactional partners. This may adversely affect parent-infant interaction during that time. Interaction during the neonatal period does not necessarily predict later interactions.
- Public Law 99-457, the Education for the Handicapped Amendments of 1986, authorizes funds for state agencies to provide services to handicapped infants from birth through 2 years of age. Each state must develop guidelines for eligibility. Individual Family Service Plans (IFSPs) and case management are a necessary focus in transition from the neonatal intensive care unit if the infants are served by special education.
- Interacting with legislators may be the most effective means to obtain funding for infant programs.

In summary, VLBW babies have a significantly increased risk for mortality and morbidity than FBW babies. Some of the major problems affecting the follow-up care of VLBW infants and their families have been reviewed in this book. With intensive neonatal care costing more than $1000 per day for each baby, and with the increased risk of poorer outcome with a lower birth weight, the ethics of saving smaller and smaller babies is an ongoing concern.

For those professionals such as special educators and occupational or physical therapists who deal almost exclusively with individuals considered to have abnormal outcomes, it is important not to lose sight of the fact that most VLBW babies have normal developmental outcomes. With collaboration among families, hospital personnel, and those disciplines responsible for follow-up health and education, one hopes to continue to see both improved mortality rates and improved quality of life for these smallest and most fragile members of our society.



Appendix

Car Seat Support for LBW Babies

by Carol Cook, M.O.T., O.T.R.

Restraining very young children in car seats when they are riding in automobiles is not only the law in all 50 states, it is a vital, common-sense safety precaution. Unfortunately, anyone who has attempted to use a standard car seat with a newborn or low birth weight baby knows that the tiny infant will slump over in a seat that is too big. Parents may not realize how dangerous that is to an infant who has trouble breathing when in this position. Towel rolls and blankets may have to be added around the infant to keep the head and body straight.

Bull and Stroup (1985) presented a method of adapting car seats for low birth weight infants. They recommended the use of a terry cloth bath roll on each side of the baby and between the baby and the crotch strap. The towel between the legs prevents the baby from slipping down in the seat. They reviewed several infant car seats. They found that car seats with a seat-back-to-crotch measurement of 14 cm (5½ inches) or less provide good support for the infant. Seats with lap pads or shields are unacceptable. Even if the shoulder straps appear too big for the infant, they must cross the infant's shoulders in order to restrain the baby.

Because the infant car seats and the car bed had not been crash tested with simulated low birth weight infants, an effort was made to verify their effectiveness and safety. Bull et al. (1988) crash tested several rear-facing infant car seats. These were the Evenflo Dyn-O-Mite, Century Infant Love Seat, Cosco First Ride, and Safe-T-Seat. The Swinger Car Bed was also tested. A 4.75 pound dummy was used for the tests. All were subjected to frontal impacts at 30 miles per hour. The dummy in the car seats had no additional padding. The car bed was tested with additional padding or a smaller bunting. All the seats and the car bed were found to restrain the dummy adequately.

The Dyn-O-Mite infant seat, which is adjustable, is recommended for babies who require a semi-reclined position. For those babies at risk for apnea, the Swinger Car Bed is recommended (Bull et al., 1988). A study by Willett et al. (1986) suggested that the semi-upright position may compromise oxygen saturation in some preterm infants.

References

Bull, M. J., and K. B. Stroup. 1985. Premature infants in car seats. *Pediatrics* 75 (2):336-339.

Bull, M. J., K. Weber, and K. B. Stroup. 1988. Automotive restraint systems for premature infants. *Journal of Pediatrics* 112:385-388.

Willett, L. D., M. P. Leuschen, L. S. Nelson, and R. M. Nelson, Jr. 1986. Risk of hypoventilation in premature infants in car seats. *The Journal of Pediatrics* 109 (2):245-248.

Supplemental Reading

Burdi, A. R., D. F. Huelke, R. G. Snyder, and G. H. Lowrey. 1969. Infants and children in the adult world of automobile safety design: Pediatric and anatomical considerations for design of child restraints. *Journal of Biomechanics* 2:267-280.

Shaw, G. 1987. Vehicular transport safety for the child with disabilities. *The American Journal of Occupational Therapy* 41 (1):35-42.

Stout, J. D., M. J. Bull, and K. B. Stroup. 1989. Safe transportation for children with disabilities. *American Journal of Occupational Therapy* 43:31-36.

Resources

Titles, addresses, and telephone numbers for organizations change frequently. The following are current at the time of publication. Many libraries carry *The Encyclopedia of Associations*, which is updated at least yearly.

Indiana State University School of Medicine
Automotive Safety for Children Program
James Whitcomb Riley Hospital for Children P-121
702 Barnhill Drive
Indianapolis, Indiana 46223

Crash Testing and Research
Transportation Research Institute
University of Michigan
2901 Baxter Road
Ann Arbor, Michigan 48109

PROFESSIONAL ORGANIZATIONS

Association for the Care of Children's Health/Child Life Council
3615 Wisconsin Ave. N.W.
Washington, D.C. 20016
(202) 244-1801

National Perinatal Association
101½ S. Union St.
Alexandria, Virginia 22314
(703) 549-5523
This organization has a developmental-intervention special interest section.

NATIONAL TOLL-FREE NUMBERS

American Foundation for the Blind . . . . . (800) 232-5463

National Down Syndrome Society . . . . . (800) 221-4602

Spina Bifida Association of America . . . . . (800) 621-3141

National Sudden Infant Death Syndrome (SIDS) Foundation . . (800) 221-SIDS

National Health Information Clearinghouse . . . . . (800) 336-4797
This organization provides agency referral information.

Information Sources

American Association of University Affiliated Programs
8605 Cameron St., Suite 406
Silver Spring, Maryland 20910
This organization can direct you to the closest university-affiliated program. UAPs provide interdisciplinary training, research, and service in the area of developmental disabilities. Many programs focus on infants and can suggest local resources and national directories on maternal and child health services.

Compassionate Friends Headquarters
P.O. Box 3696
Oak Brook, Illinois 60522-3696
Provides information and support booklets regarding the death of a child.

Infant Stimulation Education Association
UCLA Health Science Center
Los Angeles, California 90024
This organization provides bibliographies, abstracts, workshops, and other information relevant to neonatal practice.

March of Dimes Birth Defects Foundation
1275 Mamaroneck Ave.
White Plains, New York 10605
(914) 428-7100
Local chapters may provide catalogs of audiovisual materials and public information. They may also fund research, education, and service projects regarding high-risk infants.

National Center for Clinical Infant Programs
733 15th St. N.W., Suite 912
Washington, D.C. 20005
The organization provides a major newsletter, Zero to Three, *and sponsors national workshops.*

National Center for Education in Maternal and Child Health/National Maternal and Child Health Clearinghouse
38th and R Streets N.W.
Washington, D.C. 20057
Many free publications, including services for children with special needs, and parent considerations.

Parent Care
101½ S. Union St.
Alexandria, Virginia 22314-3323
(703) 836-4678
The organization sponsors national and regional workshops and provides a newsletter and information on local parent-support chapters. The focus is on parents of infants who have been in neonatal intensive care units.

Sibling Information Network
Connecticut's University Affiliated Program
991 Main St.
E. Hartford, Connecticut 06108
(703) 486-5035
Provides information regarding siblings of high-risk or disabled infants and children.

Wheelock College, Publications, Division of Continuing Education
200 The Riverway
Boston, Massachusetts 02215
Request information on booklets prepared by Project WELCOME and Project ACCESS pertaining to preterm infants.

Common Local Resources

Many resources are available by looking in your local telephone directory. Typical sources that may have information on infant developmental intervention programs, health care, or child welfare include:

Association for Retarded Citizens

Educational Service Center (Call your local school administration regarding baby programs)

Mental Health/Mental Retardation Center

Public Health and Human Services Department

Feeding Questionnaire

NAME:_____ PARENTS: _____

DATE: _____ THERAPIST:_____

ORALLY FED:_____ TUBE FED:_____

1. How many minutes does an average meal or bottle feeding take? _____
2. What consistency is the food you give your child?

   Strained (commercially prepared)_____ Junior _____

   Blended (table food) _____ Mashed_____

   Coarse _____
3. Does your child have any problems chewing crackers, meats, or carrots? _____
4. Does your child take a bottle?_____ How much liquid in the bottle? _____

   What goes into the bottle? _____ What type of nipple?_____

   Are there any extra holes in the nipple?_____
5. Does your child have difficulty drinking from a bottle? _____
6. What does your child find most offensive at mealtimes (temperature, texture or flavor of food, or noise)? _____
7. Do you use any special equipment for feeding?_____
8. Where does your child sit while being fed? Lap_____ High chair_____ Car seat _____
9. Do you consider mealtimes messy? _____
10. Can almost anyone feed your child?_____
11. Does your child occasionally bite onto the spoon and then is unable to let go?_____
12. Do you have to put the same spoonful back into your child's mouth several times? _____
13. Does your child mind being touched around the face?_____
14. What medications is your child currently taking? _____
15. Is there anything special that needs to be done while feeding your child? _____

    _____
16. Does your child have any allergies? _____

    Food _____ Medication _____

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Current Feeding Skills:

___Drinks from a bottle. Does the child hold it? _____

___Drinks from a cup. Does the child hold it? _____

___Fed by a caretaker. How? _____

___Feeds self with fingers. _____

___Feeds self with spoon. _____

___Feeds self with fork. _____

___Self-feeding with assistance. _____

___Self-feeding, independent. _____

Tube Feeding:

Gastrostomy _____ Jejuenostomy _____

Gavage: Nose _____ Mouth _____

Schedule _____ Position _____

How does the child react? _____

Feeding Schedule:

Approximate times _____

Any specific reactions to watch for: _____

Vomit? _____ Gas _____

Amount of formula per feeding _____ Type of formula _____

Amount of blended food per feeding _____ What foods have been introduced? _____

Compiled by Lyla Chustz, O.T.R.

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Maternal Support System Scale

High Risk (1, 2, 3, 4) Moderate Risk (5, 6, 7) Low Risk (8, 9, 10)

NAME _____ DATE OF HOME VISIT _____

BIRTH DATE _____ HOME VISITOR _____

Questions for the mother:

_____ 1. What is your age? _____ *(Score one point if 19 years or older.)*

_____ 2. With whom do you live?

_____ Mother only _____ Older sister _____ Grandmother _____ Boyfriend

_____ Father only _____ Both parents _____ Husband _____ Husband/boyfriend's family

_____ Alone _____ Other relative (Which relative?)

(If she lives with an extended family or has easy local access to an extended family for help and support, score one point; if she lives alone or has no or limited access to an extended family, score no points.)

_____ 3. Who will help you care for your baby?

_____Mother _____Father _____Both parents _____Older sister _____Grandmother

_____Husband/baby's father _____Boyfriend _____Husband/boyfriend's family

_____Babysitter _____Day care or nursery _____Other (brothers or younger siblings)

(Score one point for a female role model, for both parents, for the husband, or for the baby's father, or if the babysitter or day care arrangements are firm.)

_____ 4. If there is no firm babysitter or day care arrangement, does the primary support person work outside the home where the child spends the day? Is that person gone for a large part of the day? YES _____ NO _____

(Score one point if NO.)

_____5. How many times did you move during the last year?_____

(Score one point if one or none.)

_____6. How have you learned about caring for babies?

_____ Watching own mother/grandmother _____ Course in school

_____ Babysitting younger siblings regularly _____ Reading in books *regularly*

_____ Rearing other children _____ Never had regular contact with babies

(Score one point for any response except never had regular contact.)

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_____ 7. How far along were you when you went to the prenatal clinic? _____

(Score one point if during 1st trimester; no points for 2nd or 3rd trimester.)

_____ 8. Did you keep all your appointments? NO_____ YES_____ SOME_____ MOST_____

(Score one point if yes; no points for "some" or "most" or "no.")

_____ 9. If you had a need for child care assistance NOW so you could keep an appointment, who would you call on outside your family?

_____babysitter _____friends _____church group _____other _____none known now

(Score one point for any response other than "none known now.")

Home visitor's general assessment:

_____ 10. What are your feelings about the child's environment and your general impressions?

(Score one point if generally positive.)

_____TOTAL POINTS

Comments

_____

_____

_____

_____

_____

_____

_____

_____

Developed by the Dallas Neonatal Network Public Health Nurse Follow-Up Committee

Mary Elaine Jones, Ph.D., Chairperson

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Very Low Birth Weight Infant Referral for Developmental Intervention

Referral date_____ Referred from _____ (hospital or agency program)

Referred by_____ Referred to _____ _____(developmental program)

Child's name _____ Sex _____ Ethnicity _____ DOB _____

Mother's name _____ Mother's age_____ Language spoken_____

Father or other primary caregiver _____

Address where child resides: Street _____ Apartment _____

City _____ Zip Code _____ Telephone_____

Name of friend or relative _____ Telephone_____

Primary language spoken by parent/caregiver _____

Current physician or primary health care provider _____

Neonatal Information

Gravida _____ Parity _____ Delivery Method: C-Section ☐ Vaginal ☐

Birth Weight_____ Estimated Gestational Age _____ Apgar 1 min._____ 5 min. _____

Special Care Nursery Admission: ____ Intensive Care ____ Acute Care ____ Continuing Care

Additional Risk Factors

☐ Ventilated (# of days) _____ ☐ Seizures_____

☐ Bronchopulmonary Dysplasia_____ ☐ TORCH Infection _____

☐ Surgery (specify)_____ ☐ Intracranial hemorrhage (grade and location)

_____ _____

☐ Retinopathy of Prematurity _____ ☐ Apnea and Bradycardia _____

☐ _____ ☐ _____

Current Information

Bayley Scales of Infant Development: Date of test_____

Chron. Age: _____ yrs _____ mos _____ days Adj. Age: _____ yrs _____ mos _____days

Developmental Concerns _____

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	Age Equivalent	Index	Index Adjusted for Prematurity
Cognitive			
Motor			

Other Concerns _____

General Recommendations for Programming _____

_____

_____

_____

_____

_____

Medical Precautions

_____

_____

_____

_____

_____

_____

Physician's Signature _____ Date _____

Consent for Release of Information

I hereby consent to the release of medical, developmental, or social information on my child

_____ from (name of facility) _____

to _____

Signed _____ Witness _____

Relationship to Child _____ Date _____

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Developmental Program Referral (To be implemented by parent)

We recommend referring your child to a developmental program because we are concerned about your child's development and want your child to have the best opportunity to develop to full potential.

To begin the referral process:

Call

_____

_____

Tell them

- Your child has been evaluated at the following facility _____
- Your child has been noted to have the following concerns regarding development _____

  _____
- You would like to enroll the child in an infant development program.
- At chronological age _____, your child's Bayley Scales of Infant Development scores were:

  Mental Age: _____months Mental Index: _____ Mental Index: _____ (adjusted for prematurity)

  Motor Age: _____ months Motor Index: _____ Motor Index: _____ (adjusted for prematurity)

They may ask for your child's full name, the parents' full names and occupations, when the child learned to sit or walk, whether immunizations are up to date, and other pertinent information.

An application usually must be completed before your child can begin the program. You will probably need to sign releases for the program to obtain copies of your child's medical records.

Referred By _____

Program Name _____

Address _____

_____

Telephone _____

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Conversion Tables

Conversion of Pounds and Ounces to Grams

Ounces

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	—	28	57	85	113	142	170	198	227	255	283	312	340	369	397	425
1	454	482	510	539	567	595	624	652	680	709	737	765	794	822	850	879
2	907	936	964	992	1021	1049	1077	1106	1134	1162	1191	1219	1247	1276	1304	1332
3	1361	1389	1417	1446	1474	1503	1531	1559	1588	1616	1644	1673	1701	1729	1758	1786
4	1814	1843	1871	1899	1928	1956	1984	2013	2041	2070	2098	2126	2155	2183	2211	2240
5	2268	2296	2325	2353	2381	2410	2438	2466	2495	2523	2551	2580	2608	2637	2665	2693
6	2722	2750	2778	2807	2835	2863	2892	2920	2948	2977	3005	3033	3062	3090	3118	3147
7	3175	3203	3232	3260	3289	3317	3345	3374	3402	3430	3459	3487	3515	3544	3572	3600
8	3629	3657	3685	3714	3742	3770	3799	3827	3856	3884	3912	3941	3969	3997	4026	4054
9	4082	4111	4139	4167	4196	4224	4252	4281	4309	4337	4366	4394	4423	4451	4479	4508
10	4536	4564	4593	4621	4649	4678	4706	4734	4763	4791	4819	4848	4876	4904	4933	4961
11	4990	5018	5046	5075	5103	5131	5160	5188	5216	5245	5273	5301	5330	5358	5386	5415
12	5443	5471	5500	5528	5557	5585	5613	5642	5670	5698	5727	5755	5783	5812	5840	5868
13	5897	5925	5953	5982	6010	6038	6067	6095	6123	6152	6180	6209	6237	6265	6294	6322
14	6350	6379	6407	6435	6464	6492	6520	6549	6577	6605	6634	6662	6690	6719	6747	6776
15	6804	6832	6860	6889	6917	6945	6973	7002	7030	7059	7087	7115	7144	7172	7201	7228
16	7257	7286	7313	7342	7371	7399	7427	7456	7484	7512	7541	7569	7597	7626	7654	7682
17	7711	7739	7768	7796	7824	7853	7881	7909	7938	7966	7994	8023	8051	8079	8108	8136
18	8165	8192	8221	8249	8278	8306	8335	8363	8391	8420	8448	8476	8504	8533	8561	8590
19	8618	8646	8675	8703	8731	8760	8788	8816	8845	8873	8902	8930	8958	8987	9015	9043
20	9072	9100	9128	9157	9185	9213	9242	9270	9298	9327	9355	9383	9412	9440	9469	9497
21	9525	9554	9582	9610	9639	9667	9695	9724	9752	9780	9809	9837	9865	9894	9922	9950
22	9979	10007	10036	10064	10092	10120	10149	10177	10206	10234	10262	10291	10319	10347	10376	10404

Conversion of Inches to Centimeters

Inches	Centimeters	Inches	Centimeters	Inches	Centimeters
10	25.4	17	43.2	24	61.0
10½	26.7	17½	44.4	24½	62.2
11	27.9	18	45.7	25	63.5
11½	29.2	18½	47.0	25½	64.8
12	30.5	19	48.3	26	66.1
12½	31.8	19½	49.5	26½	67.4
13	33.0	20	50.8	27	68.7
13½	34.3	20½	52.1	27½	69.9
14	35.6	21	53.3	28	71.2
14½	36.8	21½	54.6	28½	72.5
15	38.1	22	55.9	29	73.8
15½	39.4	22½	57.2	29½	75.1
16	40.6	23	58.4	30	76.4
16½	41.9	23½	59.7	30½	77.6

Professional resources for parents and therapists . . .

PREMATURE BABY BOOK: A Parents' Guide to Coping and Caring in the First Years (1983)

by Helen Harrison, with Ann Kositsky, R.N.

Provide parents with valuable information on the care of their premature baby. This reliable NICU reference contains specific developmental and medical information and how-to's for when the baby comes home from the hospital. Also includes interviews with neonatologists, intensive care nurses, social workers and therapists . . . balanced with the actual experiences of parents of premature babies. **Catalog No. 4110-Y $15.95**

INFANT MOTOR DEVELOPMENT: A Look at the Phases (1988)

by Kerry Goudy, O.T.R., and Joan Winger, M.S., CCC-SLP

Up-to-date videotape provides a complete look at normal infant motor development. Currently being used in NDT training courses, this valuable resource is an outstanding teaching tool for therapists, physicians and other allied health professionals, great for parents and students too! Shows normal development from birth through 12 months and outlines four phases of normal development including infantile, preparation, modification and refinement.

Catalog No. 4141-Y $69

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3830 E. Bellevue/P.O. Box 42050
Tucson, Arizona 85733/(602) 323-7500

A Guide to Care and Management of Very Low Birth Weight Infants: A Team Approach

Enhance interagency coordination by sharing information with your team members. Specialists from various disciplines—including speech-language pathology, physical therapy, occupational therapy, nutrition, nursing, and others—offer an overview of the care of low birth weight infants and their families.

Articles in this book cover these areas—

- Family considerations
- Medical and developmental management concerns
- Developmental assessment and outcome

The information you gather from these articles will help ease the transition for these at-risk infants from hospital to home care. There are forms for continuing evaluations and referrals as well as practical advice on guiding parents in caring for these babies. The articles in this book will increase the sensitivity and awareness of everyone on your team, both inside and outside the hospital setting.

Interest Level: Professional Resource

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